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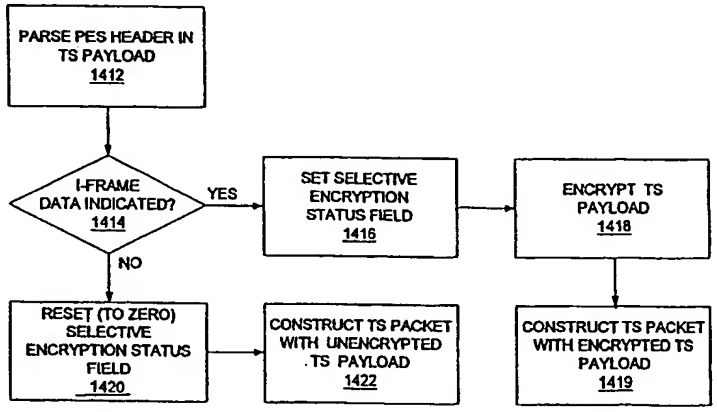

(57) Abstract

Selective encryption is provided in a process which includes: determining whether a predetermined criterion is satisfied; setting a selective encryption status field if the predetermined criterion is satisfied; and encrypting an unencrypted payload to generate an encrypted payload, and constructing a packet with the encrypted payload, if the predetermined criterion is satisfied. The predetermined criterion may be one of several criteria, each of which reduce the required amount of encryption and decryption while maaintaining a high level of security. Renewable encryption is provided in a process which includes: copying a first encrypted digital video program from a remote server to a video source; decrypting the first encrypted digital video program using a first key to generate an unencrypted digital video program; encrypting the unencrypted digital video program using a second key to generate a second encrypted digital video program; transmitting the second encrypted digital video program from the video source to the remote server; and deleting the first encrypted digital video program from the remote server.

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SELECTIVE AND RENEWABLE ENCRYPTION FOR SECURE DISTRIBUTION OF VIDEO ON-DEMAND

CROSS-REFERENCES TO RELATED APPLICATIONS

The present application is based on provisional application "Selective Encryption," Serial No. 60/131,162, filed April 26, 1999, by inventors Michael Colligan, Yong Ho Son, and Christopher Goode. The present application is also based on provisional application "Time Dependency on Pre-Encryption for Video On-Demand Systems," Serial No. 60/128,224, filed April 7, 1999, by inventor Yong Ho Son. In addition, the present application is a continuation-in-part of utility application "Secure Distribution of Video On-Demand," Serial No. 09/267,800, filed March 12, 1999, by inventors Yong Ho Son and Christopher Goode.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of video distribution networks. In particular, this invention relates to secure video distribution networks.

2. Description of the Background Art

Security is an important issue for video distribution networks. Issues of security are particularly important with regards to the distribution of digital video.

Distribution of digital cable television channels currently follows a broadcast model in that the digital cable television channels are broadcast from the broadcast source to many subscriber stations at once. Security for the distribution of

digital cable television channels also follows a broadcast model. A digital cable television channel is fully encrypted in real-time at the time of the broadcast from the broadcast source. Authorization keys allow subscribing users to decrypt and view the broadcast content. Such authorization keys must somehow, at sometime, be delivered to the subscribing users. It is not practical to deliver authorization keys at the same time that encrypted content is broadcast because verification of the delivery is difficult to do immediately and interactively using current cable television networks. Hence, delivery of the authorization keys occurs periodically on a time-based schedule, where the periodicity of the delivery is known as a time quantum or time epoch. The time epoch is typically related to the billing cycle (for example, monthly) for the cable television service.

Unlike distribution of digital cable television channels, distribution of digital video on-demand (VOD) follows a pointcast model in that the content is transmitted from a video server to each individual viewer. Due to the nature of pointcasting, a security scheme for digital VOD which is based on the model provided by security for cable television broadcasts would be impractical and expensive. First, fully encrypting the digital VOD in real-time every time the digital video is transmitted from the server to an individual viewer is quite expensive in both cost and space usage for encryption equipment. Second, having a time epoch correlated to the billing cycle of the digital VOD service (for example, monthly) is a scheduling scheme that may create security risks which inhibits optimal protection of the content.

SUMMARY OF THE INVENTION

The present invention solves the problems discussed above by selective and renewable encryption for secure distribution of digital video on-demand. Selective encryption is provided in a process which includes: determining whether a predetermined criterion is satisfied; setting a selective encryption status field if the predetermined criterion is satisfied; and encrypting an unencrypted payload to generate an encrypted payload, and constructing a packet with the encrypted payload, if the predetermined criterion is satisfied. The predetermined criterion may be one of several criteria, each of which reduce the required amount of encryption and decryption while maintaining a high level of security. Renewable encryption is provided in a process which includes: copying a first encrypted digital video program from a remote server to a video source; decrypting the first encrypted digital video program using a first key to generate an unencrypted digital video program; encrypting the unencrypted digital video program using a second key to generate a second encrypted digital video program; transmitting the second encrypted digital video program from the video source to the remote server; and deleting the first encrypted digital video program from the remote server.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a conventional cable distribution network (100).

Fig. 2 is a flow chart depicting a conventional insecure process (200) for distributing video content via a conventional cable distribution network (100).

Fig. 3A is a flow chart depicting a conventional secure process (300) for distributing premium video content via a conventional cable distribution network (100).

Fig. 3B is a flow chart depicting a conventional secure process (350) for distributing digital television broadcasts via a conventional cable distribution network (100).

Fig. 4 is a schematic diagram of a cable distribution network (400) including a video on-demand source (402) in accordance with a preferred embodiment of the present invention.

Fig. 5A is a flow chart depicting a secure process (500) for distributing video on-demand content via a cable distribution network (400) in accordance with a first aspect of the present invention.

Fig. 5B is a flow chart depicting a secure process (550) for distributing video on-demand content via a cable distribution network (400) in accordance with a second aspect of the present invention.

Fig. 6 is a flow chart depicting a secure process (600) for distributing video on-demand content via a cable distribution network (400) in accordance with a third aspect of the present invention.

Fig. 7 is a flow chart depicting a secure process (700) for distributing video on-demand content via a cable distribution network (400) in accordance with a fourth aspect of the present invention.

Fig. 8 is a schematic diagram showing interconnected components relating to encryption within the VOD source (402) in accordance with the fourth aspect of the present invention.

Fig. 9 is a flow chart depicting an initial process (900) for encrypting (502, 602, or 702) content at a VOD source (402) in accordance with a preferred embodiment of the present invention.

Fig. 10 is a flow chart depicting a renewal process (1000) for encrypting (502, 602, or 702) content at a VOD source (402) in accordance with a preferred embodiment of the present invention.

Fig. 11A is a schematic diagram showing a conventional MPEG-2 transport stream (TS) packet (1100).

Fig. 11B is a schematic diagram showing a conventional MPEG-2 Packetized Elementary Stream (PES) packet (1150).

Fig. 12A is a flow chart depicting a process for selective encryption (1200) utilizing a payload unit start indicator (SI) in accordance with a first embodiment of the present invention.

Fig. 12B is a flow chart depicting a process for selective decryption (1250) utilizing the payload unit start indicator(SI) in accordance with the first embodiment of the present invention.

Fig. 13 is a schematic diagram showing a TS packet (1100) including a selective encryption status field (1302) in accordance with a second embodiment of the present invention.

Fig. 14A is a flow chart depicting a first process for encryption (1400) in accordance with the second embodiment of the present invention.

Fig. 14B is a flow chart depicting a second process for encryption (1410) in accordance with the second embodiment of the present invention.

Fig. 14C is a flow chart depicting a third process for encryption (1430) in accordance with the second embodiment of the present invention.

Fig. 14D is a flow chart depicting a fourth process for encryption (1440) in accordance with the second embodiment of the present invention.

Fig. 14E is a flow chart depicting a fifth process for encryption (1450) in accordance with the second embodiment of the present invention.

Fig. 14F is a flow chart depicting a sixth process for encryption (1460) in accordance with the second embodiment of the present invention.

Fig. 15 is a flow chart depicting a process for decryption (1500) in accordance with the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENTS

Fig. 1 is a schematic diagram of a conventional cable distribution network (100). The conventional cable distribution network (100) typically includes one or more broadcast sources (102), one or more premium broadcast sources (104), one or more distribution centers (106), one or more secondary distribution networks (108), and a plurality of subscriber stations (110).

The broadcast source (102) may be, for example, a local television station. For instance, an affiliate station of a major network such as ABC, NBC, CBS, FOX, or UPN. The premium broadcast source (104) may be, for example, a premium channel such as HBO, Showtime, Cinemax, and so on. The sources (102) and (104) may be coupled via a primary distribution network to the distribution center (106). The distribution center (106) may be, for example, a cable head-end. The distribution center (106) may be coupled via a secondary distribution network (108) to the subscriber stations (110). The secondary distribution network (108) comprises may include, for example, various amplifiers, bridges, taps, and drop cables. Finally, the subscriber stations (110) may be, for example, set-top boxes and associated television equipment for viewing the video content by end users.

Fig. 2 is a flow chart depicting a conventional insecure process (200) for distributing video content via a conventional cable distribution network. First, a non-premium video signal is transported (202) from the broadcast source (102) to the distribution center (106). At the distribution center (106), the video signal is multiplexed (204) with other signals to generate a multiplexed signal. The multiplexed signal is then distributed (206) from the distribution center (106) via the secondary distribution network (108) to the subscriber stations (110). At the subscriber stations (110), the multiplexed signal is demultiplexed (208) to isolate the video signal, and then the video signal is displayed 210, typically, on a television monitor.

Fig. 3A is a flow chart depicting a conventional secure process (300) for distributing video content via a conventional cable distribution network. First, a premium video signal is encrypted (302) to generate an encrypted signal. The encrypted signal is transported (304) from the premium broadcast source (104) to the distribution center (106).

At the distribution center (106), the video signal is decrypted (306) to regenerate the premium video signal. The premium video signal is then scrambled (308) – re-encrypted with a different key and multiplexed (310) with other signals to generate a multiplexed signal. The multiplexed signal is then distributed (312) from the distribution center (106) via the secondary distribution network (108) to the subscriber stations (110).

At the subscriber stations (110), the multiplexed signal is demultiplexed (314) to isolate the scrambled video signal, the scrambled video signal is unscrambled (316), and then the video signal is displayed (318), typically, on a television monitor connected to a set-top box. The process in Fig. 3 is a typical conventional process for delivering premium video using scrambling. Other conventional processes also exist.

Fig. 3B is a flow chart depicting a conventional secure process (350) for distributing premium digital television broadcasts via a conventional cable distribution network (100). The process (350) begins in a first step (351) when a new billing cycle starts. In a second step (352), new authorizations are distributed from the premium broadcast source (104) to subscriber stations (110) via the conventional cable distribution network (100). Of course, the new authorizations are distributed to only subscriber stations (110) that are subscribing to the premium digital TV for the new billing cycle.

In a third step (354), the encryption system in the premium broadcast source (104) changes to a new encryption key for use in encrypting the premium digital TV broadcast. The new encryption key corrresponds to the new billing cycle. In a fourth step (356), the encryption system in the premium broadcast source (104) fully encrypts the premium digital TV in real-time using the new encryption key. In a fifth step (358), the encrypted premium digital TV is broadcast to the subscriber stations (110) via the conventional cable distribution network (100). In a sixth step (360), the subscriber stations (110) receive and fully decrypt the encrypted premium digital TV using the new authorizations. Of course, only subscriber stations (110) which are subscribing to the premium digital TV broadcast for the new billing cycle have the new authorizations and so only they are able to fully decrypt the encrypted broadcast.

In a seventh step (362), a determination is made as to whether an end of the new billing cycle is being reached. If the end is not being reached, then the process (350) loops back to the fourth step (356) where the premium digital TV continues to be encrypted in real-time and then broadcast. Otherwise, if the end is being reached, then the process (350) goes on back to the first step (351) where a new billing cycle starts.

Fig. 4 is a schematic diagram of a cable distribution network (400) including a video on-demand source (402) in accordance with a preferred embodiment of

the present invention. In addition to the components of the conventional cable distribution network (100) shown in Fig. 1, the cable distribution network (400) shown in Fig. 4 includes a video on-demand source (402) and a remote server (404). The video on-demand source (402) may house, for example, a collection of video programs such as, for example, movies. As shown in Fig. 4, the remote server (404) may be located within the distribution center (106). The remote server (404) may include, for example, a parallel processing computer configured to be a video server, a disk drive array to store video data, and a video session manager to provide session control of the video data flowing to and from the video server.

Fig. 5A is a flow chart depicting a secure process (500) for distributing video on-demand content via a cable distribution network (400) in accordance with a first aspect of the present invention. The process depicted in Fig. 5A may be called a store, decrypt, and re-encrypt process.

First, a video program is encrypted (502) by a video on-demand source (402) to generate an encrypted program in a first encrypted form. The encrypted program is transported (504) via a primary distribution network from the video on-demand source (402) to a remote server (404) within a distribution center (106). The encrypted program is then stored (506) in the remote server (404).

Subsequently, when the remote server (404) receives (508) a request for transmission of the video program from a subscriber station (110), the remote server (404) responds by first decrypting (510) the video program from the first encrypted form. A first key is may be used to accomplish such decryption (510), and such key may have been received from the video on-demand source (402) via a communication channel that is separate from the one used to transmit the video program. After the video program is

decrypted (510), the remote server (404) re-encrypts (512) the video program into a second encrypted form using a second key.

The second key may be a public key of a public key encryption system. Such a public key encryption system uses two different key: a public key to encrypt data and a private key to decrypt data. In that case, decryption would be accomplished using a corresponding private key of the public key encryption system. Examples of such a public key encryption system is encryption under the PGP (Pretty Good Privacy) system or under the RSA (Rivest, Shamir, and Adleman) system. Alternatively, the second key may be a private key of a private key encryption system. Such a private key encryption system uses a single private key to encrypt and decrypt data. Examples of such a private key encryption system is encryption under the Data Encryption Standard (DES) or under triple-DES which involves applying DES three times to enhance security. The private key(s) itself may be transmitted from the remote server (404) to the subscriber station (110) while encrypted in a third encrypted form.

After the video program is re-encrypted (512), the re-encrypted program in the second encrypted form (and the second key if necessary) is multiplexed (514) with other signals to generate a multiplexed signal. The multiplexed signal is then distributed (516) via the secondary distribution network (108) to the subscriber stations (110).

At the subscriber stations (110), the multiplexed signal is demultiplexed (518) to isolate the re-encrypted program in the second encrypted form (and the second key if necessary), the re-encrypted program is decrypted (520) from the second encrypted form to generate the unencrypted video program, and then the video program is displayed (522), typically, on a television monitor connected to set-top box.

Fig. 5B is a flow chart depicting a secure process (550) for distributing video on-demand content via a cable distribution network (400) in accordance with a

second aspect of the present invention. The process (550) depicted in Fig. 5B may be called a decrypt, re-encrypt, and store process. In comparison with the process (500) in Fig. 5A, the process (550) in Fig. 5B decrypts (510) and re-encrypts (512) the video program before the video program is stored (506) in the remote server (404).

First, a video program is encrypted (502) by a video on-demand source (402) to generate an encrypted program in a first encrypted form. The encrypted program is transported (504) via a primary distribution network from the video on-demand source (402) to a remote server (404) within a distribution center (106). At this point, the remote server (510) decrypts (510) the video program from the first encrypted form. A first key is may be used to accomplish such decryption (510), and such key may have been received from the video on-demand source (402) via a communication channel that is separate from the one used to transmit the video program. After the video program is decrypted (510), the remote server (404) re-encrypts (512) the video program into a second encrypted form using a second key. After the decryption (510) and re-encryption (510), the re-encrypted program is then stored (506) in the remote server (404).

Note that step (506) in Fig. 5B differs from step (506) in Fig. 5A in that step (506) in Fig. 5B involves storing the video program in the second encrypted form while step (506) in Fig. 5A involves storing the video program in the first encrypted form.

Subsequently, when the remote server (404) receives (508) a request for transmission of the video program from a subscriber station (110), the remote server (404) responds by multiplexing (514) the re-encrypted program in the second encrypted form (and the second key if necessary) with other signals to generate a multiplexed signal. The multiplexed signal is then distributed (516) via the secondary distribution network (108) to the requesting subscriber station (110).

At the subscriber stations (110), the multiplexed signal is demultiplexed (518) to isolate the re-encrypted program in the second encrypted form (and the second key if necessary), the re-encrypted program is decrypted (520) from the second encrypted form to generate the unencrypted video program, and then the video program is displayed (522), typically, on a television monitor connected to set-top box.

Fig. 6 is a flow chart depicting a secure process (600) for distributing video on-demand content via a cable distribution network (400) in accordance with a third aspect of the present invention. The process (600) depicted in Fig. 6 may be called a pass-through process.

First, a video program is encrypted (602) by a video on-demand source (402) to generate an encrypted program in a first encrypted form. The encrypted program is transported (604) via a primary distribution network from the video on-demand source (402) to a remote server (404) within a distribution center (106). A key to decrypt the encrypted program may also be transported from the source (402) to the server (404). The encrypted program is then stored (606) in the remote server (404).

The key may be a public key of a public key encryption system. Such a public key encryption system uses two different key: a public key to encrypt data and a private key to decrypt data. In that case, decryption would be accomplished using a corresponding private key of the public key encryption system. Examples of such a public key encryption system is encryption under the PGP (Pretty Good Privacy) system or under the RSA (Rivest, Shamir, and Adleman) system. Alternatively, the key may be a private key of a private key encryption system. Such a private key encryption system uses a single private key to encrypt and decrypt data. Examples of such a private key encryption system is encryption under the Data Encryption Standard (DES) or under triple-DES which involves applying DES three times to enhance security. The private

key(s) itself may be transmitted from the source (402) to the server (404) while encrypted in a second encrypted form. Alternatively, the private key(s) may be transported from the source (402) to the server (404) via a communication channel which is separate from the communication channel used to transport the video program from the source (402) to the server (404).

Subsequently, when the remote server (404) receives (608) a request for transmission of the video program from a subscriber station (110), the remote server (404) responds by multiplexing (610) the encrypted program in the first encrypted form (and the key if necessary) with other signals to generate a multiplexed signal. The multiplexed signal is then distributed (612) via the secondary distribution network (108) to the requesting subscriber station (110).

At the subscriber stations (110), the multiplexed signal is demultiplexed (614) to isolate the encrypted program in the first encrypted form (and the key if necessary), the encrypted program is decrypted (616) from the first encrypted form to generate the unencrypted video program, and then the video program is displayed (618), typically, on a television monitor connected to set-top box.

Fig. 7 is a flow chart depicting a secure process (700) for distributing video on-demand content via a cable distribution network (400) in accordance with a fourth aspect of the present invention. The process (700) depicted in Fig. 7 may be called a multiple-layer encryption process. In comparison with the process (600) in Fig. 6, the process (700) in Fig. 7 "pre-encrypts" (702) the video program at the source (402), completes encryption (704) of the video program at the remote server (404), and fully decrypts (706) the video program at the subscriber station (110).

The pre-encryption step (702) may be implemented by applying a single DES encryption or a double DES encryption. If the pre-encryption step (702) uses a

single DES encryption, then the completion of encryption step (704) may be implemented by applying a double DES encryption to achieve triple-DES encryption. Similarly, if the pre-encryption step (702) uses a double DES encryption, then the completion of encryption step (704) may be implemented by applying a single DES encryption to achieve triple-DES encryption. In either case, the video program is transported from the remote server (404) to the subscriber station (110) while under triple-DES encryption. As long as the subscriber station has the three keys required, it will be able to fully decrypt (706) the triple-DES encryption to obtain the unencrypted video program.

Fig. 8 is a schematic diagram showing interconnected components relating to encryption within the VOD source (402) in accordance with the fourth aspect of the present invention. The interconnected components include: a content source (802), a encryption coordinator (804), a content manager (806), a encryptor (808), and a encryptor controller (810). The operation of these components is discussed below in relation to Figs. 9 and 10.

Fig. 9 is a flow chart depicting an initial process (900) for encrypting (502, 602, or 702) content at a VOD source (402) in accordance with the present invention. This initial process (900) occurs when the particular digital video content is introduced for the first time from the VOD source (402) to the remote server (404).

In a first step (902), the digital video content is loaded from the content source (802) to the encryption coordinator (804). In a second step (904), the encryption coordinator (804) receives the content and schedules the content for encryption. The scheduling of the encryption is performed by the encryption coordinator (804) under control of the content manager (806). The content manager holds the schedule information regarding times when a particular content, e.g. a movie, is scheduled to be encrypted (identified for which one of the encryption mechanisms described here) and

distributed to a set of Remote Video Servers. The scheduling depends upon the other content already scheduled for encryption and upon the throughput of the encryptor. The schedule will be assigned and adjusted as necessary to accommodate the priorities and timing requirements of the various content to be encrypted.

In a third step (906), at the scheduled time for encryption, the content is loaded by the encryptor (808). In a fourth step (908), the encryptor (808) uses a particular key corresponding to the appropriate time epoch to encrypt the content. The encryption of the content is performed by the encryptor (808) under control of the encryptor controller (810). The encryptor controller is the first component of the end to end key management system. Since the encryption process may be single or multi-level encryption, e.g. DVB-Superscrambling or Triple DES, the encryption keys may change many times, periodically or aperiodically, during the encryption of a single content, i.e. every 5 minutes of a movie. These keys with index references to where the key change occurred in the content (markers), are delivered to the Remote Video Servers in a secure mechanism, e.g. RSA. In a fifth step (910), the encrypted content is passed back to the encryption coordinator (804). The encrypted content is then introduced (604) from the VOD source (402) to the remote server (404).

Fig. 10 is a flow chart depicting a renewal process (1000) for encrypting (502, 602, or 702) content at a VOD source (402) in accordance with the present invention. This renewal process (1000) occurs whenever encryption is to be renewed for particular digital video content stored on the remote server (404).

Prior to renewal process (1000), the digital video is stored on the remote server (404) in a encrypted form under a key of a "first" (not necessarily initial) time epoch. The first step (1002) of the renewal process (1000) relates to the nearing of the end of the first time epoch. In accordance with a preferred embodiment of the present

invention, a time epoch does not need to correspond to a billing cycle. Rather, time epochs may be selected in order to afford proper protection for the content during the lifetime of the content on the remote server (404).

In a second step (1004), once the end of the first time epoch nears, the digital video content is copied from the remote server (404) back to the encryption coordinator (804) in the VOD source (402). In a third step (1006), the encryption coordinator (804) receives the content and schedules the content for encryption. The scheduling of the encryption is performed by the encryption coordinator (804) under control of the content manager (806).

In a fourth step (1008), at the scheduled time for encryption, the content is loaded by the encryptor (808). In a fifth step (1010), the encryptor (808) uses the particular key corresponding to the first time epoch to decrypt the content. Subsequently, in a sixth step (1012), the encryptor (808) uses a particular key corresponding to a "second" time epoch to re-encrypt the content. The decryption and re-encryption of the content is performed by the encryptor (808) under control of the encryptor controller (810). In a seventh step (1014), the re-encrypted content is passed back to the encryption coordinator (804). In an eighth step (1016), the re-encrypted content is then sent from the VOD source (402) to the remote server (404).

In a ninth step (1018), the first time epoch ends and the second time epoch begins. Finally, in a tenth step (1020), once the second time epoch begins, the remote server begins serving the version of the encrypted content which relates to the second time epoch and deletes the version which relates to the first time epoch.

Fig. 11A is a schematic diagram showing a conventional MPEG-2 transport stream (TS) packet (1100). The TS packet (1100) comprises a TS header (1102) and a TS payload (1104). The general contents of the TS header (1102) and TS payload

(1104) are described below. Further details are given in various publications, including the MPEG-2 standard itself, formally referred to as ISO 13818.

As shown in Fig. 11A, the transport header (1102) may include a sync_byte, a transport_error_indicator (TEI), a payload_unit_start_indicator (SI), a transport_priority (TP), a packet ID (PID), a transport_scrambling_control (SC), an adaptation_field_control (AFC), a continuity_counter (CC), and an (optional) adaptation_field (AF). The sync_byte is used for synchronization purposes and generally has a fixed value of 0x47. The TEI is used to indicate an uncorrectable bit error exists in the current TS packet. The SI is used to indicate the presence in the transport payload (1104) of a new PES (packetized elementary stream) packet or a new TS-PSI (transport stream-program specific information) section. The TP is used to indicate a higher priority for the current TS packet. The PID is used to distinguish between elementary streams and so is used by a subscriber station (110) to find, identify, and reconstruct programs from the transport stream. The SC is used to indicate the scrambling mode of the transport payload (1104). The AFC is used to indicate the presence of an adaptation field. The CC increments with each nonrepeated TS packet having the corresponding PID. Finally, the AF may contains flags and indicators, a program clock reference, plus other data.

The TS payload (1104) includes PES packets which are described further below.

Fig. 11B is a schematic diagram showing a conventional MPEG-2 Packetized Elementary Stream (PES) packet (1150). The PES packet (1150) comprises a PES header (1152) and a PES payload (1154). The general contents of the PES header (1152) and PES payload (1104) are described below. Further details are given in various publications, including the MPEG-2 standard itself, formally referred to as ISO 13818.

As shown in Fig. 11B, the PES header (1152) includes a start_code_prefix, a stream_id, a PES_packet_length, optional fields, and padding_bytes. The start_code_prefix is a string of 23 or more binary 0s, followed by a binary 1. the start_code_prefix is followed by the stream_id. The stream_id comprises 8 bits which are used to label the PES, as well as to specify the type of PES. The PES_packet_length is used to indicate the number of bytes in the PES packet. Optional fields may include various fields. For PES packets carrying video, optional fields of particular significance include a presentation time stamp (PTS) and a decoding time stamp (DTS). The PTS tells the decoder when to display a video frame. The DTS tells the decoder when to decode a video frame. Finally, padding_bytes comprise fixed 8-bit values equal to 0xFF which are to be discarded by the decoder.

The PES payload (1154) includes PES packet data bytes which are contiguous bytes of data from the elementary stream. The elementary stream may consist of compressed data from a video source, or an audio source, or a data source.

Fig. 12A is a flow chart depicting a process for selective encryption (1200) utilizing the payload unit start indicator (SI) in accordance with a first embodiment of the present invention. This process (1200) may be utilized to reduce the amount of encryption required while maintaining a high level of security. This process (1200) is performed during the construction of the TS packet (1100).

In a first step (1202), a determination is made as to whether the TS payload (1104) will contain a new PES packet or a new TS-PSI section. If the TS payload (1104) will not contain a new PES packet or a new TS-PSI section, then in a second step (1204) the TS packet (1100) is constructed with the SI flag is reset to zero, and in a third step (1206) the TS packet (1100) is constructed with an unencrypted TS

payload (1104). In alternate embodiments (not shown), the third step (1206) may occur before or in parallel with the second step (1204).

Otherwise, if the TS payload (1104) will contain a new PES packet or a new TS-PSI section, then in a fourth step (1208) the TS packet (1100) is constructed with the SI flag set to one, in a fifth step (1210) the TS payload (1104) is encrypted, and in a sixth step (1212) the TS packet (1100) is constructed with the encrypted TS payload (1104). In alternate embodiments (not shown), the fifth and sixth steps (1210 and 1212) may occur before or in parallel with the fourth step (1208). In this way, the amount of encryption required is advantageously reduced since only TS payloads (1104) containing a new PES packet or a new TS-PSI section will require encryption. Nevertheless, a high level of security is maintained because the beginning portion of each PES packet and TS-PSI section will be encrypted.

Fig. 12B is a flow chart depicting a process for selective decryption (1250) using a payload unit start indicator in accordance with the first embodiment of the present invention. This process (1250) is utilized in conjunction with the process of Fig. 12A (1200) to reduce the amount of decryption required while maintaining a high level of security. This process (1250) is performed when the transport payload (1104) is decrypted (510, 616, or 706) either at the remote server (404) or at the subscriber station (110).

In a first step (1252), the payload unit start indicator (SI) flag is scanned. In a second step (1254), a determination is made as to whether the SI flag is set. If the SI flag is set, then in a third step (1256) the TS payload (1104) is decrypted to undo the encryption (1210). If the SI flag is not set, then in a fourth step (1258) the TS payload (1104) is not decrypted to undo the encryption (1210).

In this way, the amount of decryption required is advantageously reduced since only TS payloads (1104) containing a new PES packet or a new TS-PSI section will require decryption to undo the encryption (1210). Nevertheless, a high level of security is maintained because the beginning portion of each PES packet and TS-PSI section will require decryption to undo the encryption (1210).

Fig. 13 is a schematic diagram showing a TS packet (1100) including a selective encryption status field (1302) in accordance with a second embodiment of the present invention. As shown in Fig. 13, the selective encryption status field (1302) is pre-appended before the TS header (1102) in the structure of the TS packet (1100). Selective encryption status field is either prepended or the transport Scrambling Control (SC) flags are used to mark the selected encryption.

Fig. 14A is a flow chart depicting a first process for encryption (1400) in accordance with the second embodiment of the present invention. The first process (1400) corresponds to a highest level of security, where the TS payload (1104) is encrypted for each and every TS packet (1100).

In accordance with this first process, in a first step (1402), the selective encryption status field (1302) is set. This first step (1402) is done for all TS packets (1100). In a second step (1404), the TS payload (1104) is encrypted. Since the selective encryption status field (1302) is set for all TS packets (1100), the TS payload (1104) is encrypted for all TS packets (1100). In a third step (1406), the TS packet (1100) is constructed using the encrypted TS payload for all TS packets (1100).

Fig. 14B is a flow chart depicting a second process for encryption (1410) in accordance with the second embodiment of the present invention. The second process (1410) corresponds to an intermediate level of security, where the TS payload (1104) is

encrypted only if it includes video data for a MPEG-2 I-frame (Intra frame). An I-frame contains full picture frames and are the least compressed type of frame.

In a first step (1412), all PES headers (1152) to be sent are parsed. In a second step (1414), a determination is made from the result of the parsing as to whether the current TS payload (1104) includes video data for an I-frame. On selective encryption, one of three modes are used to determine the selection of what TS packet to encrypt. Usually, the reference display information that is necessary to decoding is selected, i.e. I-Frame in a Group Of Pictures (GOP). Without the I-Frames, B-Frames and P-Frames cannot be used. First method is through the use of a marker that is prepended to the start of selected TS packets, before the sync byte. Second is through the use of information provided or added in the adaptation field of the PES headers. Third is through overloading existing fields in the header. An example of this is to use the Scrambling Control (SC) flags to tell the encryptor which TS packets to encrypt.

If I-frame data is indicated, then in a third step (1416) the selective encryption status field (1302) is set to one for the current TS packet (1100), in a fourth step (1418) the current TS payload (1104) is encrypted, and in a fifth step (1419) the current TS packet (1100) is constructed with the encrypted TS payload. Otherwise, if no I-frame data is indicated, then in a sixth step (1420) the selective encryption status field (1302) is reset to zero, and in a seventh step (1422) the TS packet (1100) is constructed with an unencrypted TS payload (1104).

Fig. 14C is a flow chart depicting a third process for encryption (1430) in accordance with the second embodiment of the present invention. The third process (1430) is similar to the second process (1410), except that in the third process (1430) the TS payload (1104) is encrypted if it includes video data for either a MPEG-2 I-frame or a MPEG-2 P-frame(Predicted frame). This third process (1430) would provide a level of

security somewhere in between the levels provided by the first and the second process (1400 and 1410).

P-frames are predicted from past I or P frames. A third type of MPEG-2 frame is a B-frame (Bidirectional predicted frame). B-frames are predicted from past and future I and P frames. B frames offer the greatest compression of the three frame types.

Step-wise, the third process (1430) has a different second step (1432) compared with the second step (1414) of the second process (1410). In the second step (1432) of the third process (1430). a determination is made from the result of the parsing as to whether the current TS payload (1104) includes video data for an I or a P frame.

If I or P frame data is indicated, then in a third step (1416) the selective encryption status field (1302) is set to one for the current TS packet (1100), in a fourth step (1418) the current TS payload (1104) is encrypted, and in a fifth step (1419) the current TS packet (1100) is constructed with the encrypted TS payload. Otherwise, if neither I nor P frame data is indicated, then in a sixth step (1420) the selective encryption status field (1302) is reset to zero, and in a seventh step (1422) the TS packet (1100) is constructed with an unencrypted TS payload (1104).

Fig. 14D is a flow chart depicting a fourth process for encryption (1440) in accordance with the second embodiment of the present invention. The fourth process (1440) is similar to the second process (1410), except that in the fourth process (1430) the TS payload (1104) is encrypted if it includes a decode time stamp (DTS) and/or a presentation time stamp (PTS).

The DTS and PTS are included in PES headers (1152) in order to indicate to the decoder when to decode and present, respectively, a video frame. Without the DTS and PTS, a decoder cannot properly decode and present the video data.

Step-wise, the fourth process (1440) has a different second step (1442) compared with the second step (1414) of the second process (1410). In the second step (1442) of the fourth process (1440). a determination is made from the result of the parsing as to whether the current TS payload (1104) includes a DTS and/or PTS.

If a DTS and/or PTS is indicated, then in a third step (1416) the selective encryption status field (1302) is set to one for the current TS packet (1100), in a fourth step (1418) the current TS payload (1104) is encrypted, and in a fifth step (1419) the current TS packet (1100) is constructed with the encrypted TS payload. Otherwise, if neither DTS nor PTS is indicated, then in a sixth step (1420) the selective encryption status field (1302) is reset to zero, and in a seventh step (1422) the TS packet (1100) is constructed with an unencrypted TS payload (1104).

Fig. 14E is a flow chart depicting a fifth process for encryption (1450) in accordance with the second embodiment of the present invention. The fifth process (1450) is similar to the second process (1410), except that in the fifth process (1450) the TS payload (1104) is encrypted if it is selected by a counter.

Step-wise, the fifth process (1450) has different first and second steps than the second process (1410). In the first step (1452), a counter is incremented. In the second step (1454), a determination is made as to whether the counter has been incremented to a next periodic subset of counts (for example, to a next subset of ten counts).

If the counter has been incremented to a next periodic subset of counts, then in a third step (1416) the selective encryption status field (1302) is set to one for the current TS packet (1100), in a fourth step (1418) the current TS payload (1104) is encrypted, and in a fifth step (1419) the current TS packet (1100) is constructed with the encrypted TS payload. Otherwise, if the counter is still within a same periodic subset of

counts, then in a sixth step (1420) the selective encryption status field (1302) is reset to zero, and in a seventh step (1422) the TS packet (1100) is constructed with an unencrypted TS payload (1104).

Fig. 14F is a flow chart depicting a sixth process for encryption (1460) in accordance with the second embodiment of the present invention. The sixth process (1460) is similar to the second process (1410), except that in the sixth process (1450) the TS payload (1104) is encrypted if it is selected by a random selection.

Step-wise, the sixth process (1460) has different first and second steps than the second process (1410). In the first step (1462), a random number is generated. In the second step (1454), a determination is made as to whether the random number selected is within a predetermined subset of a set of possible random numbers (for example, within a subset from 0 to 9 of a set from 0 to 99).

If the random number selected is within the predetermined subset, then in a third step (1416) the selective encryption status field (1302) is set to one for the current TS packet (1100), in a fourth step (1418) the current TS payload (1104) is encrypted, and in a fifth step (1419) the current TS packet (1100) is constructed with the encrypted TS payload. Otherwise, if the random number selected is outside of the predetermined subset, then in a sixth step (1420) the selective encryption status field (1302) is reset to zero, and in a seventh step (1422) the TS packet (1100) is constructed with an unencrypted TS payload (1104).

Fig. 15 is a flow chart depicting a process for decryption (1500) in accordance with the second embodiment of the present invention. The decryption process (1500) in Fig. 15 is utilized in conjunction with one of the six encryption processes (1400, 1410, 1430, 1440, 1450, and 1460) shown in Figs. 14A-F. This decryption process

(1500) is performed when the transport payload (1104) is decrypted (510, or 616, or 706) either at the remote server (404) or at the subscriber station (110).

In a first step (1502), the selective encryption status field (1302) is scanned. In a second step (1504), a determination is made as to whether the status field (1302) is set. If the status field (1302) is set, then in a third step (1506) the TS payload (1104) is decrypted to undo the encryption (1418). If the status field (1302) is not set, then in a fourth step (1508) the TS payload (1104) is not decrypted to undo the encryption (1418).

In this way, the amount of decryption required is advantageously reduced since only select TS payloads (1104) will require decryption to undo the encryption (1418). Nevertheless, a substantial level of security is maintained because select TS payloads (1104) will require decryption to undo the encryption (1418).

It is to be understood that the specific mechanisms and techniques which have been described are merely illustrative of one application of the principles of the invention. For example, while the present invention is described in application to video on-demand, it also has some application in broadcast video. Numerous additional modifications may be made to the methods and apparatus described without departing from the true spirit of the invention.

In the above description as well as in the following claims, a field or flag may be configured such that it is set to indicate a first state and reset to indicate a second state. Nevertheless, it is well understood in the art that the field or flag may be equivalently configured such that it is reset to indicate the first state and set to indicate the second state.

WHAT IS CLAIMED IS:

1. A secure method for providing digital video programming, the method comprising:

determining whether a predetermined criterion is satisfied;

setting a selective encryption status field if the predetermined criterion is satisfied;

encrypting an unencrypted payload to generate an encrypted payload, and constructing a packet with the encrypted payload, if the predetermined criterion is satisfied;

resetting the selective encryption status field if the predetermined criterion is unsatisfied;

constructing the packet with the unencrypted payload, if the predetermined criterion is unsatisfied; and

transmitting the packet.

2. The method of claim 1, wherein the predetermined criterion comprises an indication that intra frame data is contained in the unencrypted payload.

3. The method of claim 1, wherein the predetermined criterion comprises an indication that the payload includes data from a group of data including intra frame data and predicted frame data.

4. The method of claim 1, wherein the predetermined criterion comprises an indication that the payload includes a time stamp.

5. The method of claim 1, wherein the predetermined criterion comprises a counter being incremented to a next periodic subset of counts.

6. The method of claim 1, wherein the predetermined criterion comprises a random number being selected within a predetermined subset of a set of possible random numbers.

7. The method of claim 1, wherein the predetermined criterion is always satisfied.

8. The method of claim 1, wherein the predetermined criterion comprises an indication that the unencrypted payload includes a new packetized elementary stream packet, and the selective encryption status field comprises a payload unit start indicator flag.

9. The method of claim 1, wherein the predetermined criterion comprises an indication that the unencrypted payload includes a new program specific information section, and the selective encryption status field comprises a payload unit start indicator flag.

10. The method of claim 1, further comprising:

receiving the packet;

scanning the selective encryption status field;

determining whether the selective encryption status field is set; and

decrypting the encrypted payload if the selective encryption status field is set.

11. The method of claim 1, wherein the payload comprises a transport stream payload, and the packet comprises a transport stream packet.

12. The method of claim 1, wherein the selective encryption status field is preappended to the transport stream packet.

13. The method of claim 1, wherein the digital video programming comprises video on-demand.

14. The method of claim 1, wherein the digital video programming comprises broadcast video.

15. An apparatus for securely providing digital video programming, the apparatus comprising:

a determining device configured to determine whether a predetermined criterion is satisfied;

a setting device configured to set a selective encryption status field if the predetermined criterion is satisfied;

an encrypting device configured to encrypt an unencrypted payload to generate an encrypted payload, and a first constructing device configured to construct a packet with the encrypted payload, if the predetermined criterion is satisfied;

a resetting device configured to reset the selective encryption status field if the predetermined criterion is unsatisfied;

a second constructing device configured to construct the packet with the unencrypted payload, if the predetermined criterion is unsatisfied; and

a transmitting device configured to transmit the packet.

16. A secure method for providing digital video programming, the method comprising:

copying a first encrypted digital video program from a remote server to a video source;

decrypting the first encrypted digital video program using a first key to generate an unencrypted digital video program;

encrypting the unencrypted digital video program using a second key to generate a second encrypted digital video program;

transmitting the second encrypted digital video program from the video source to the remote server; and

deleting the first encrypted digital video program from the remote server.

17. The method of claim 16, wherein the first key corresponds to a first time epoch during which the remote server provides the first encrypted digital video program to subscriber stations, and the second key corresponds to a second time epoch during which the remote server provides the second encrypted digital video program to the subscriber stations.

18. The method of claim 17, further comprising, prior to deleting the first encrypted digital video program from the server, transitioning from the first time epoch to the second time epoch.

19. The method of claim 18, wherein the first and second time epochs do not correspond to billing cycles.

20. The method of claim 16, further comprising, prior to decrypting the first encrypted digital video program, scheduling the first encrypted digital video program for renewal of encryption.

21. The method of claim 16, further comprising, prior to copying the first encrypted digital video program, a process for introducing an initial encrypted digital video program to the remote server.

22. An apparatus for securely providing digital video programming, the apparatus comprising:

an encryption coordinator configured to receive a first encrypted digital video program from a remote server;

an encryptor configured to decrypt the first encrypted digital video program using a first key to generate an unencrypted digital video program and to encrypt the unencrypted digital video program using a second key to generate a second encrypted digital video program,

wherein the encryption coordinator receives the second encrypted digital video program from the encryptor and transmits the second encrypted digital video program to the remote server.

23. The apparatus of claim 22, wherein, prior to decrypting the first encrypted digital video program, the encryption coordinator schedules the first encrypted digital video program for renewal of encryption.

24. An apparatus for securely providing digital video programming to remote servers, the apparatus comprising:

a content manager for holding schedule information regarding times when video programs are scheduled to be decrypted, re-encrypted, and distributed to the remote servers; and

a key manager coupled to the content manager for tracking keys to decrypt and keys to re-encrypt the video programs.

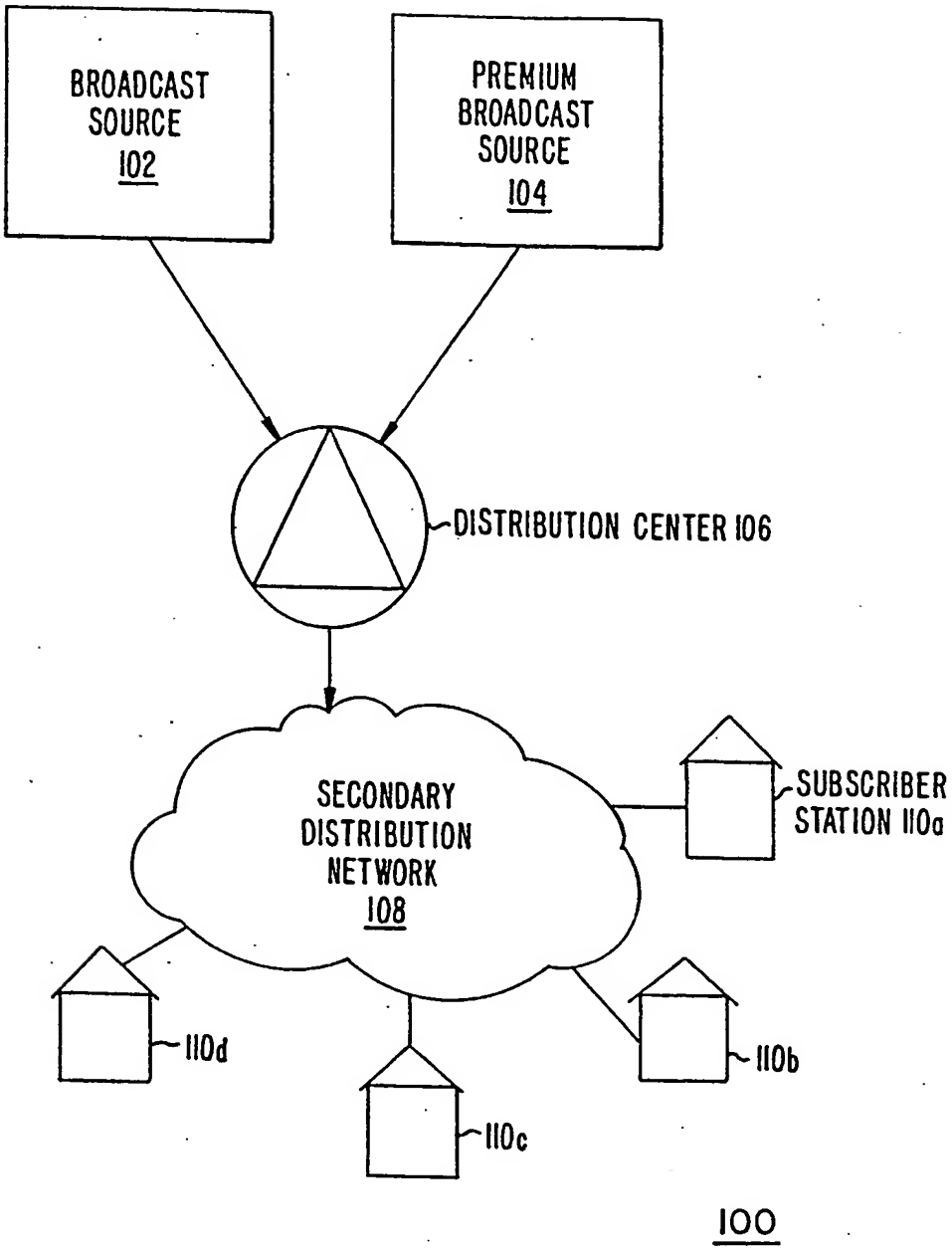

FIG. 1. (PRIOR ART)

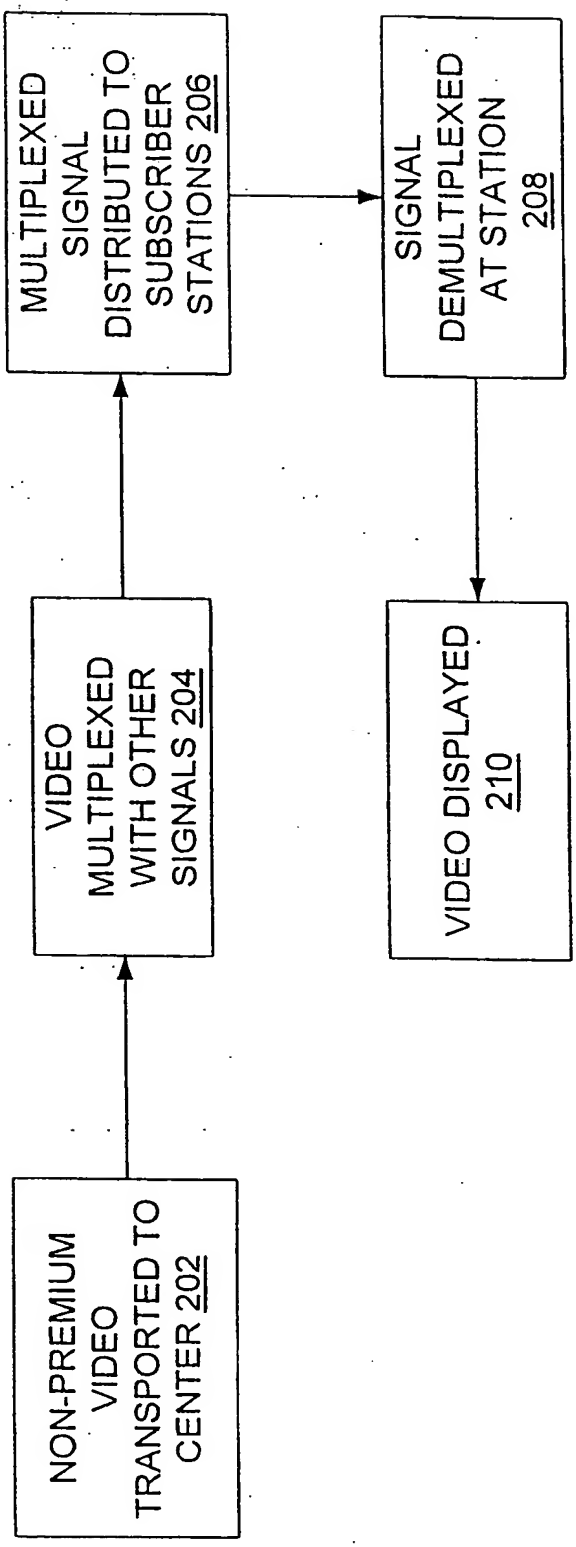

FIG. 2. (PRIOR ART)

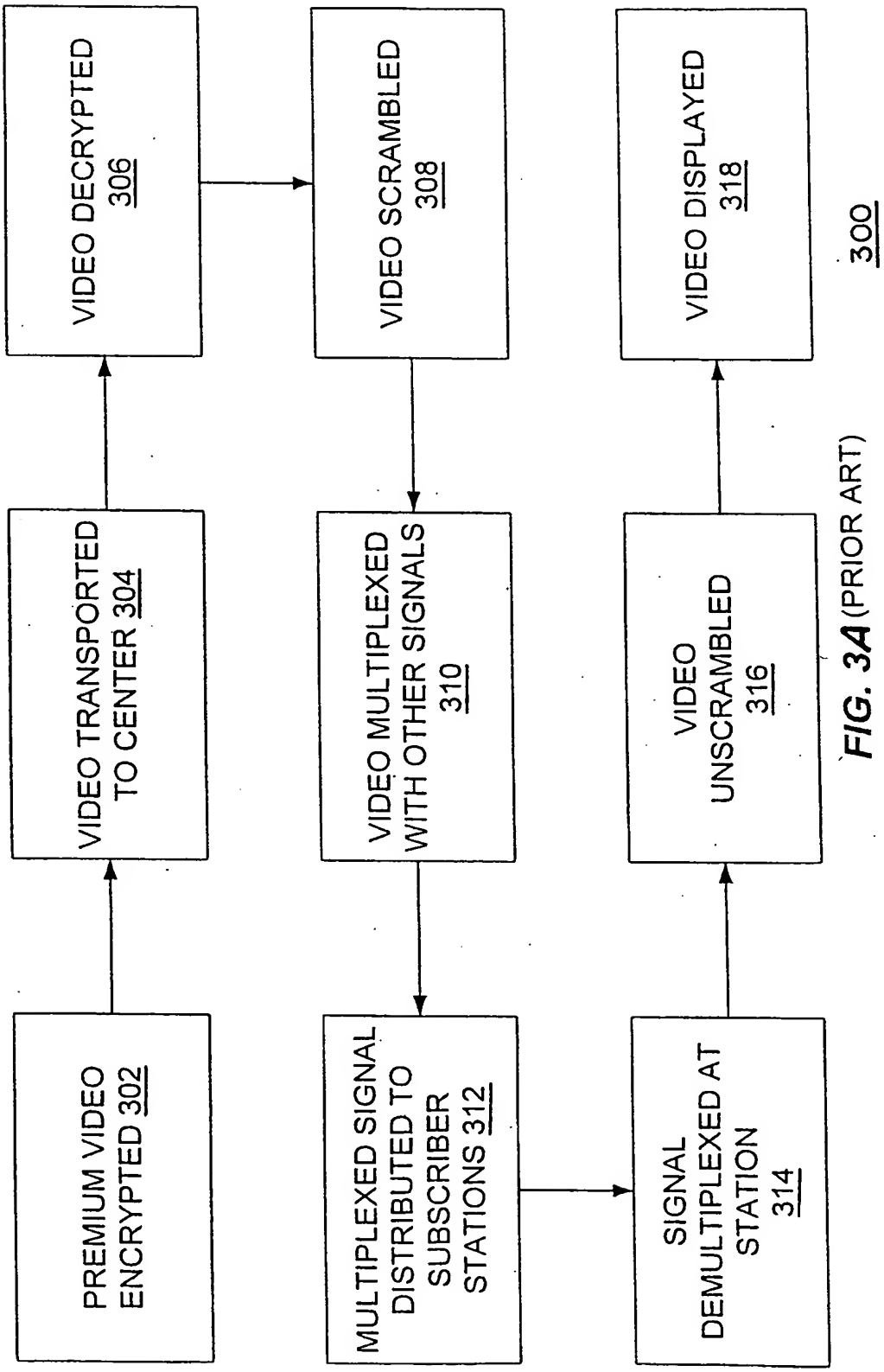

FIG. 3A (PRIOR ART)

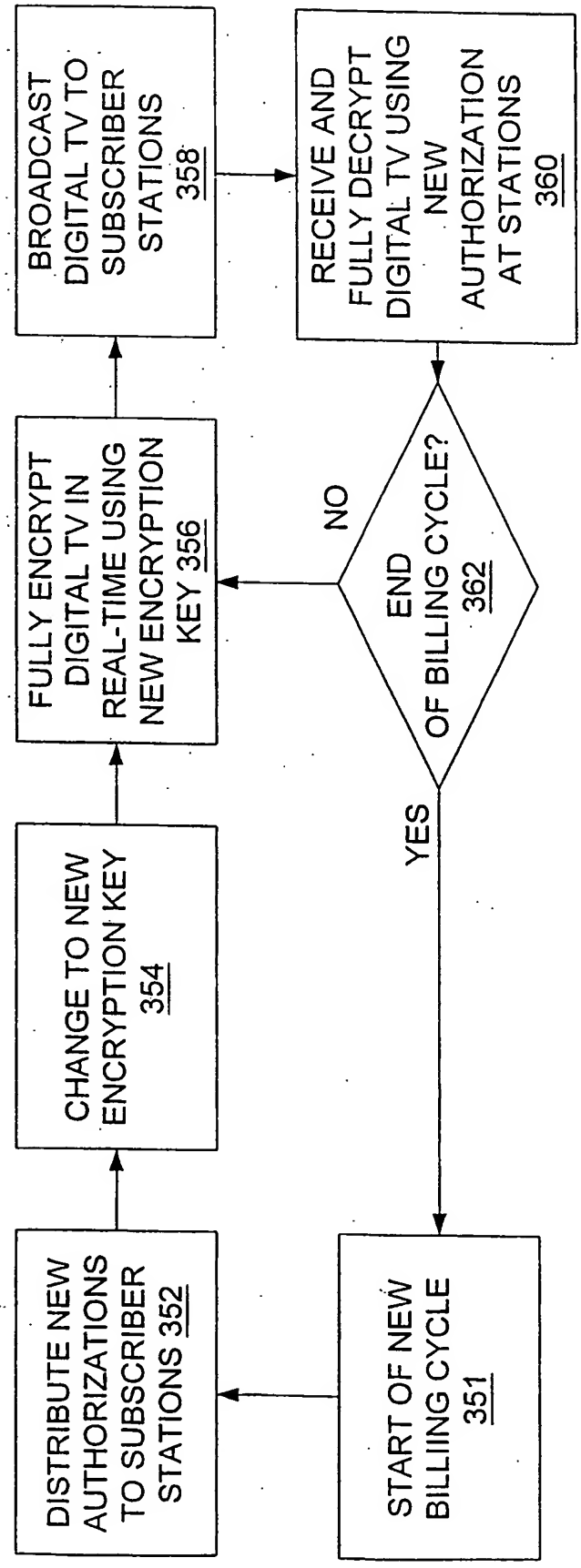

FIG. 3B. (PRIOR ART)

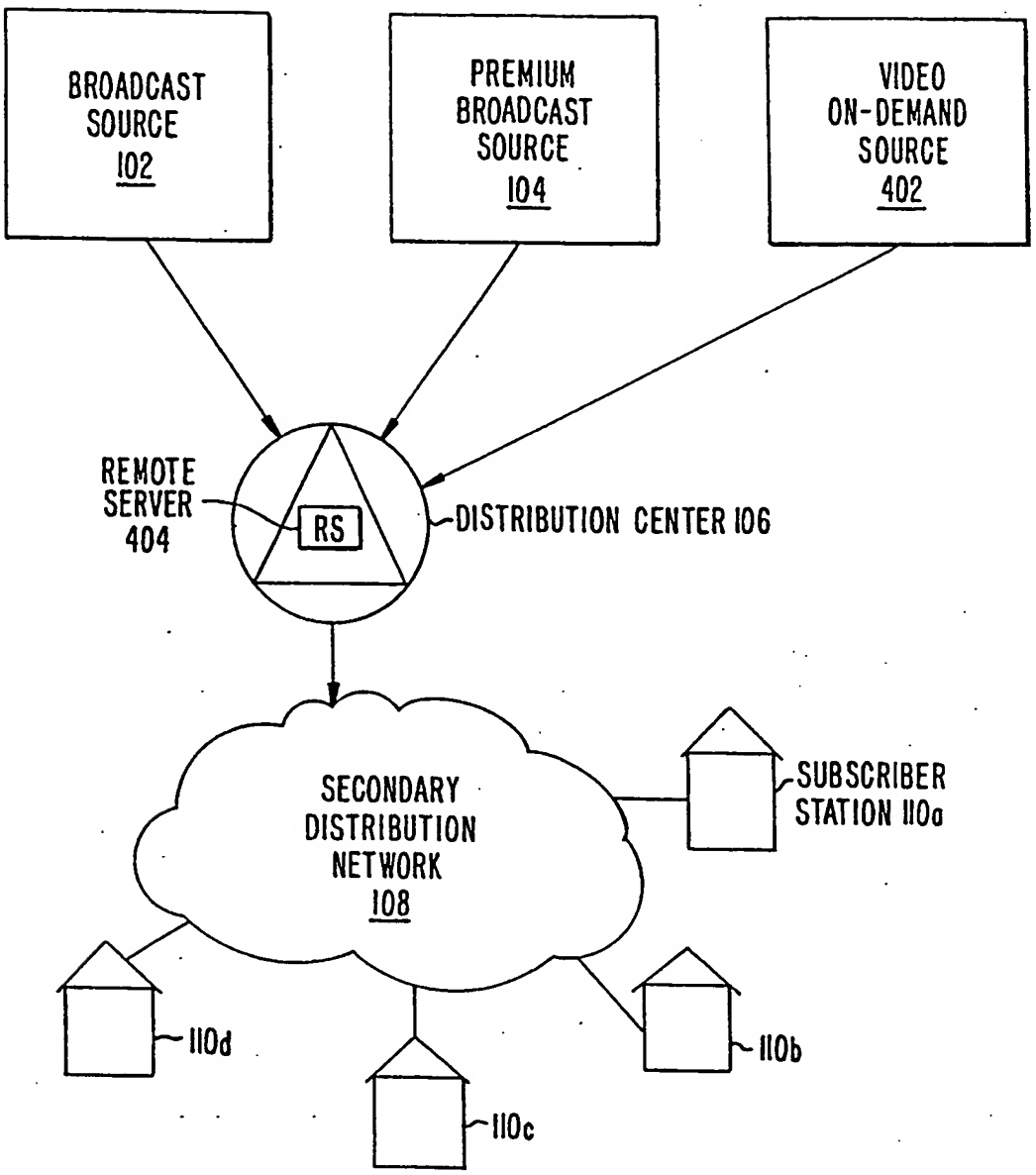
BROADCAST SOURCE 102
PREMIUM BROADCAST SOURCE 104
VIDEO ON-DEMAND SOURCE 402
REMOTE SERVER 404
RS
DISTRIBUTION CENTER 106
SECONDARY DISTRIBUTION NETWORK 108
SUBSCRIBER STATION 110a
110d
110c
110b
400

FIG. 4.

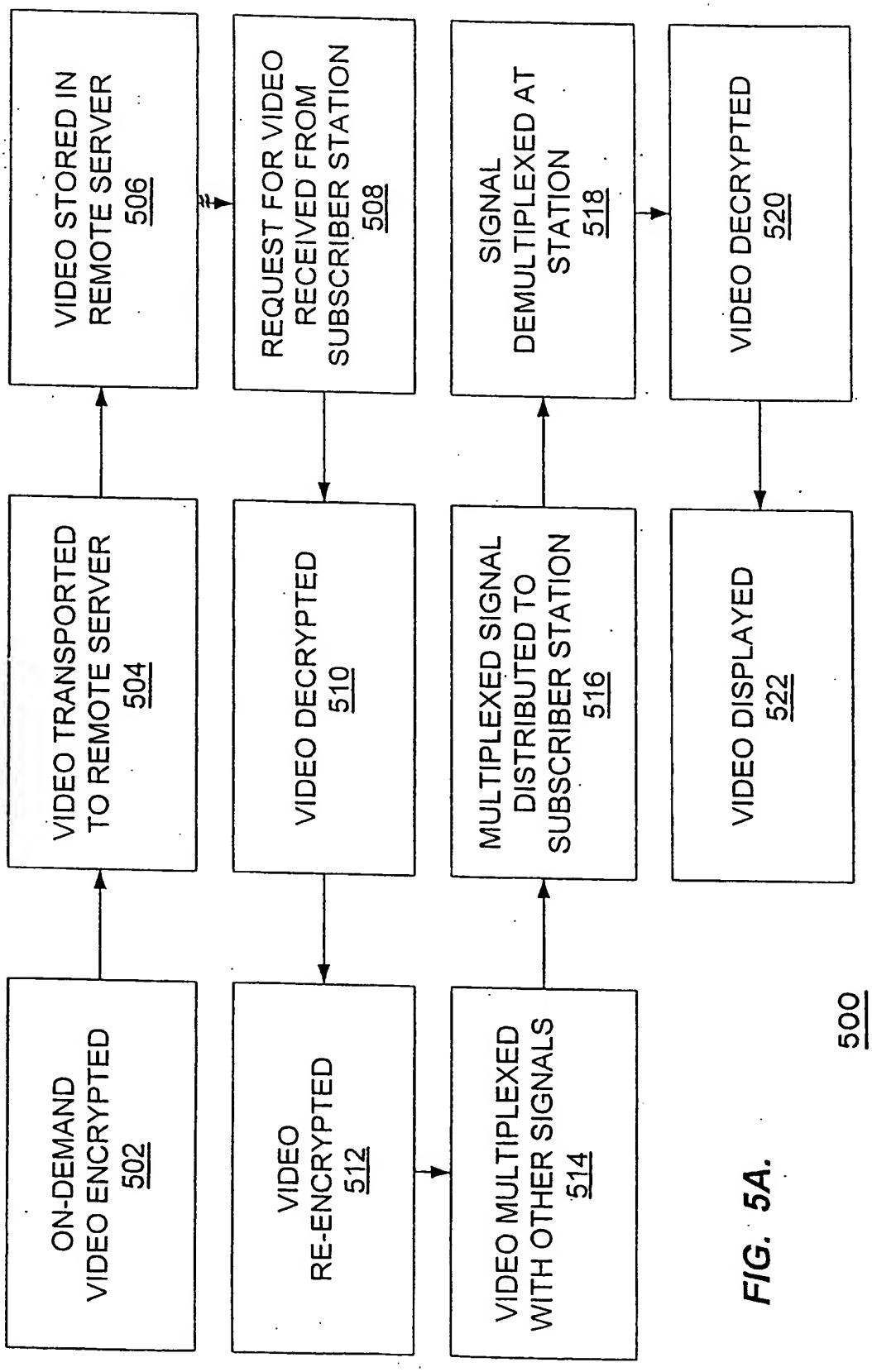
ON-DEMAND VIDEO ENCRYPTED 502
VIDEO TRANSPORTED TO REMOTE SERVER 504
VIDEO STORED IN REMOTE SERVER 506
VIDEO RE-ENCRYPTED 512
VIDEO DECRYPTED 510
REQUEST FOR VIDEO RECEIVED FROM SUBSCRIBER STATION 508
VIDEO MULTIPLEXED WITH OTHER SIGNALS 514
MULTIPLEXED SIGNAL DISTRIBUTED TO SUBSCRIBER STATION 516
SIGNAL DEMULTIPLEXED AT STATION 518
VIDEO DISPLAYED 522
VIDEO DECRYPTED 520
500

FIG. 5A.

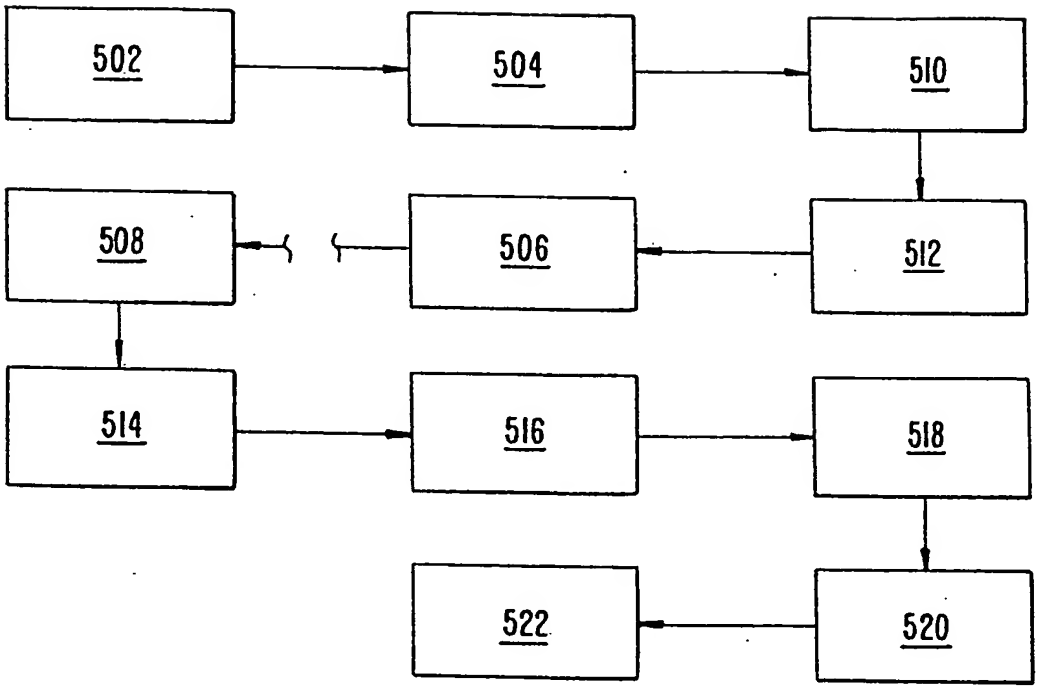

FIG. 5B.

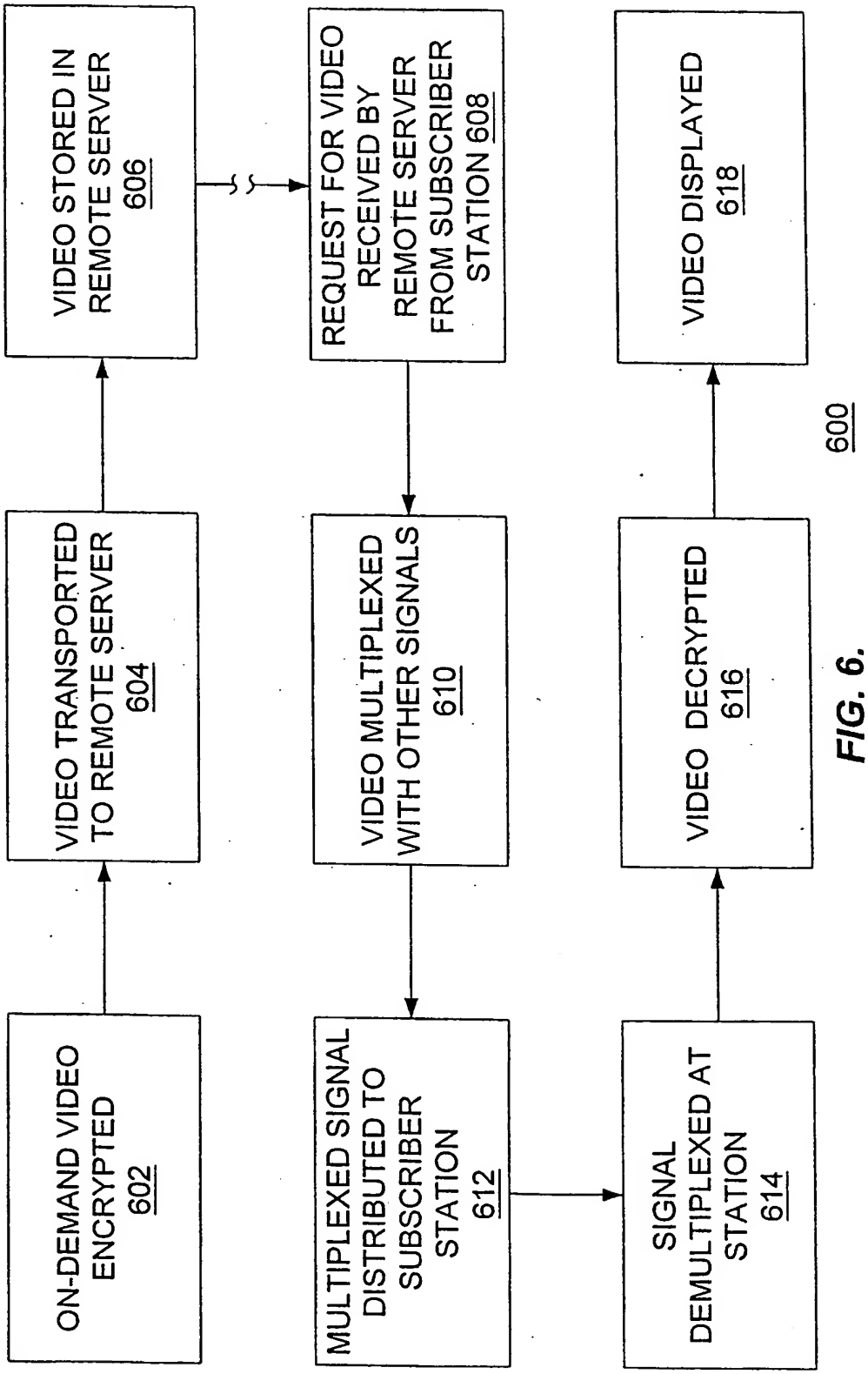
ON-DEMAND VIDEO ENCRYPTED 602
VIDEO TRANSPORTED TO REMOTE SERVER 604
VIDEO STORED IN REMOTE SERVER 606
REQUEST FOR VIDEO RECEIVED BY REMOTE SERVER FROM SUBSCRIBER STATION 608
MULTIPLEXED SIGNAL DISTRIBUTED TO SUBSCRIBER STATION 612
VIDEO MULTIPLEXED WITH OTHER SIGNALS 610
SIGNAL DEMULTIPLEXED AT STATION 614
VIDEO DECRYPTED 616
VIDEO DISPLAYED 618
600

FIG. 6.

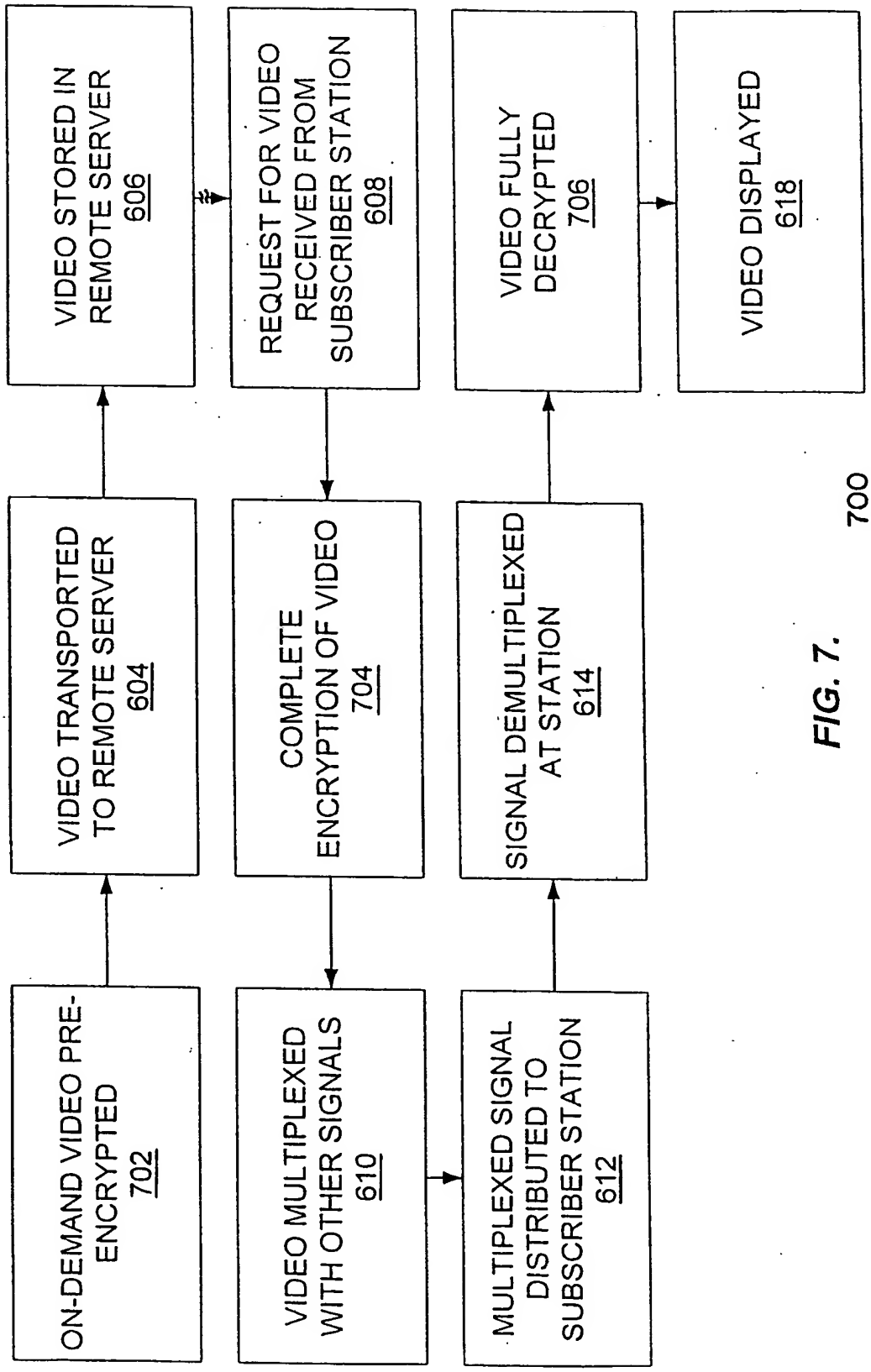
ON-DEMAND VIDEO PRE-ENCRYPTED 702
VIDEO TRANSPORTED TO REMOTE SERVER 604
VIDEO STORED IN REMOTE SERVER 606
VIDEO MULTIPLEXED WITH OTHER SIGNALS 610
COMPLETE ENCRYPTION OF VIDEO 704
REQUEST FOR VIDEO RECEIVED FROM SUBSCRIBER STATION 608
MULTIPLEXED SIGNAL DISTRIBUTED TO SUBSCRIBER STATION 612
SIGNAL DEMULTIPLEXED AT STATION 614
VIDEO FULLY DECRYPTED 706
VIDEO DISPLAYED 618

FIG. 7. 700

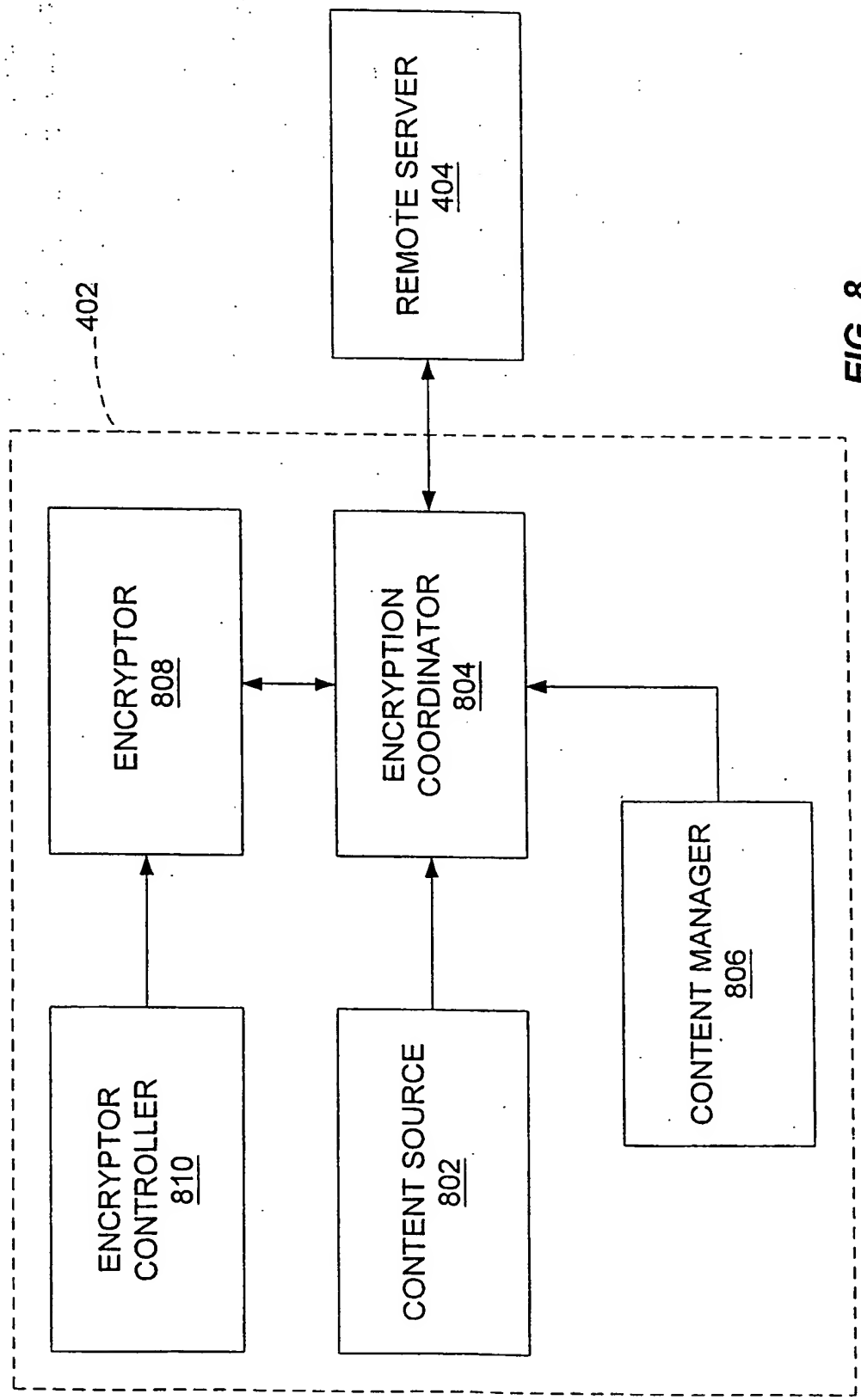
REMOTE SERVER
404
402
ENCRYPTOR
808
ENCRYPTION
COORDINATOR
804
CONTENT MANAGER
806
ENCRYPTOR
CONTROLLER
810
CONTENT SOURCE
802

FIG. 8.

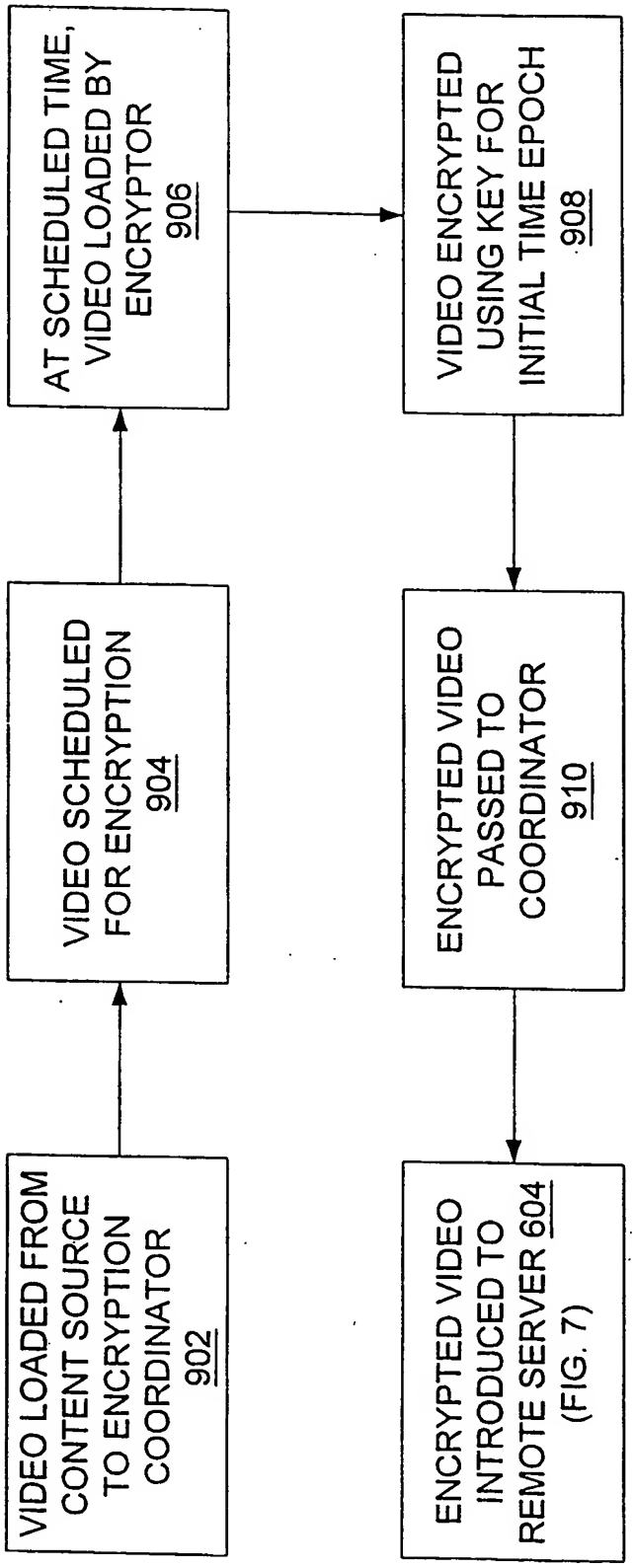
VIDEO LOADED FROM CONTENT SOURCE TO ENCRYPTION COORDINATOR 902
VIDEO SCHEDULED FOR ENCRYPTION 904
AT SCHEDULED TIME, VIDEO LOADED BY ENCRYPTOR 906
VIDEO ENCRYPTED USING KEY FOR INITIAL TIME EPOCH 908
ENCRYPTED VIDEO PASSED TO COORDINATOR 910
ENCRYPTED VIDEO INTRODUCED TO REMOTE SERVER 604 (FIG. 7)
900

FIG. 9.

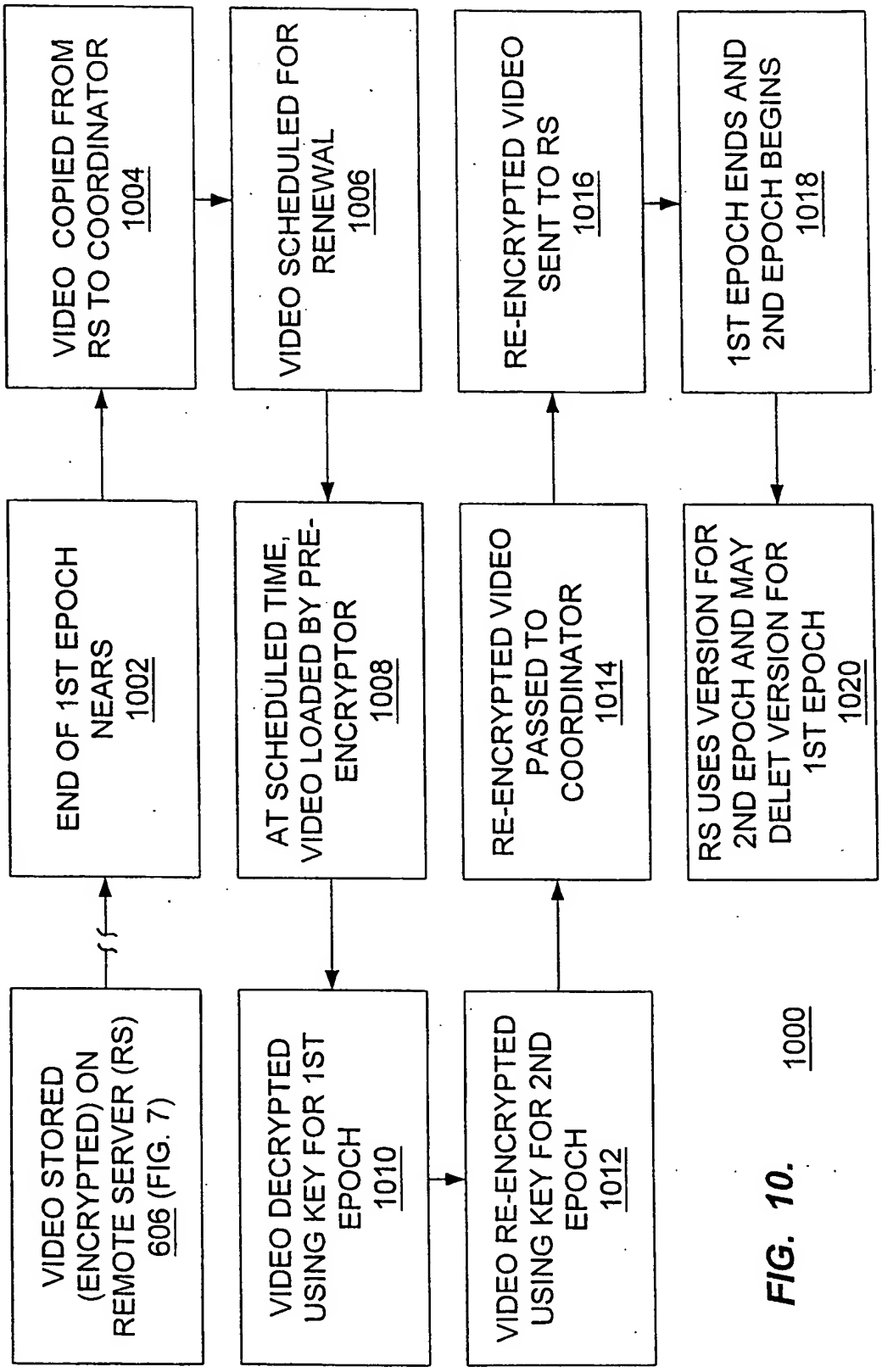
VIDEO STORED (ENCRYPTED) ON REMOTE SERVER (RS) 606 (FIG. 7)
END OF 1ST EPOCH NEARS 1002
VIDEO COPIED FROM RS TO COORDINATOR 1004
VIDEO DECRYPTED USING KEY FOR 1ST EPOCH 1010
AT SCHEDULED TIME, VIDEO LOADED BY PRE-ENCRYPTOR 1008
VIDEO SCHEDULED FOR RENEWAL 1006
VIDEO RE-ENCRYPTED USING KEY FOR 2ND EPOCH 1012
RE-ENCRYPTED VIDEO PASSED TO COORDINATOR 1014
RE-ENCRYPTED VIDEO SENT TO RS 1016
RS USES VERSION FOR 2ND EPOCH AND MAY DELET VERSION FOR 1ST EPOCH 1020
1ST EPOCH ENDS AND 2ND EPOCH BEGINS 1018

FIG. 10. 1000

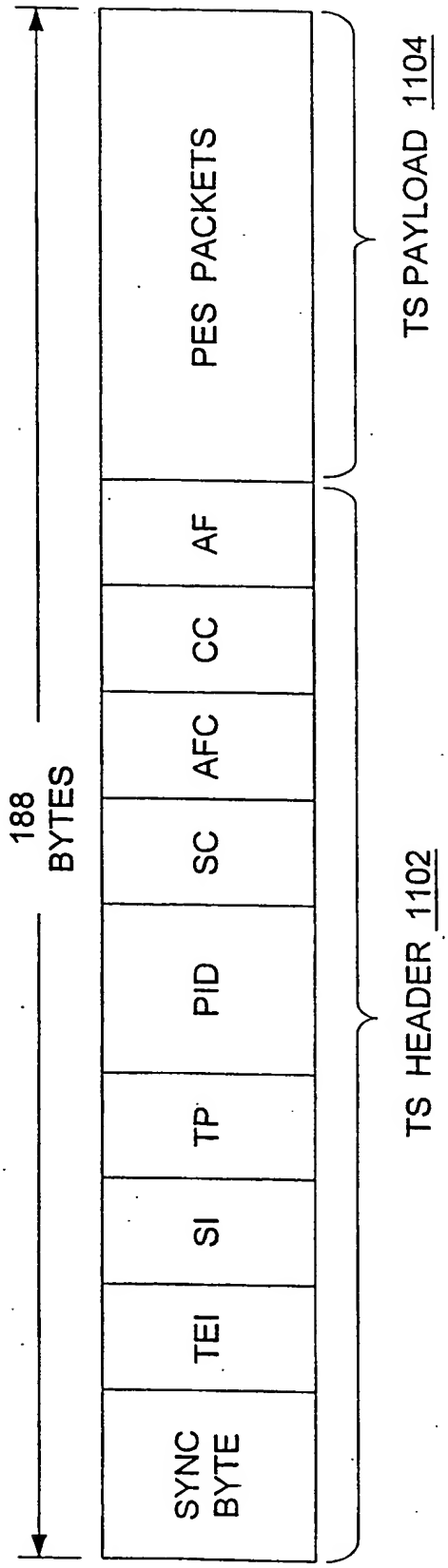

FIG. 11A. (PRIOR ART)

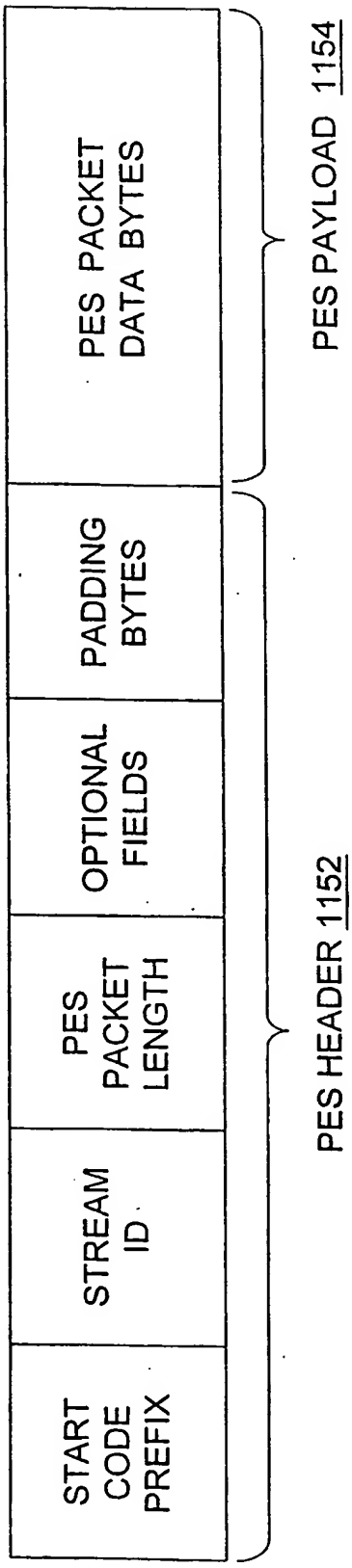

FIG. 11B. (PRIOR ART)

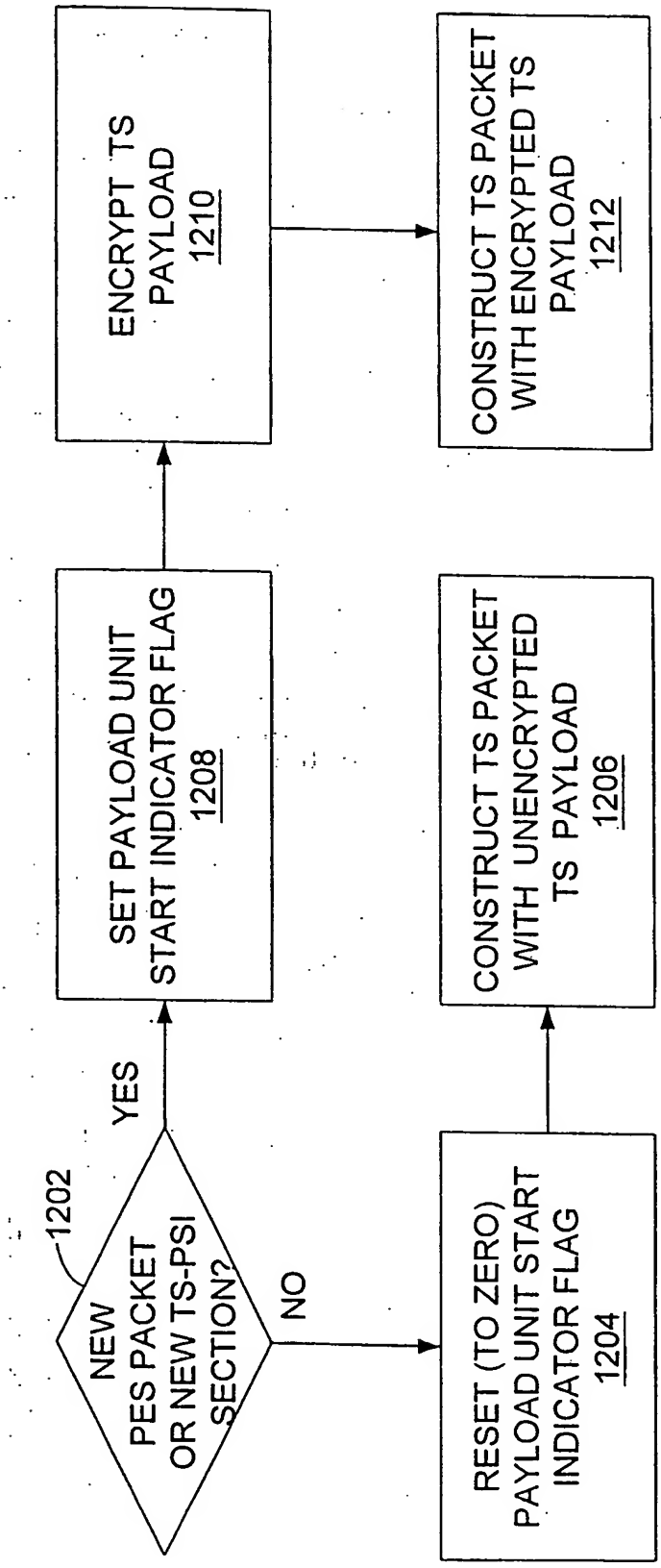
1200
1202
NEW PES PACKET OR NEW TS-PSI SECTION?
YES
NO
SET PAYLOAD UNIT START INDICATOR FLAG 1208
ENCRYPT TS PAYLOAD 1210
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD 1212
RESET (TO ZERO) PAYLOAD UNIT START INDICATOR FLAG 1204
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD 1206

FIG. 12A.

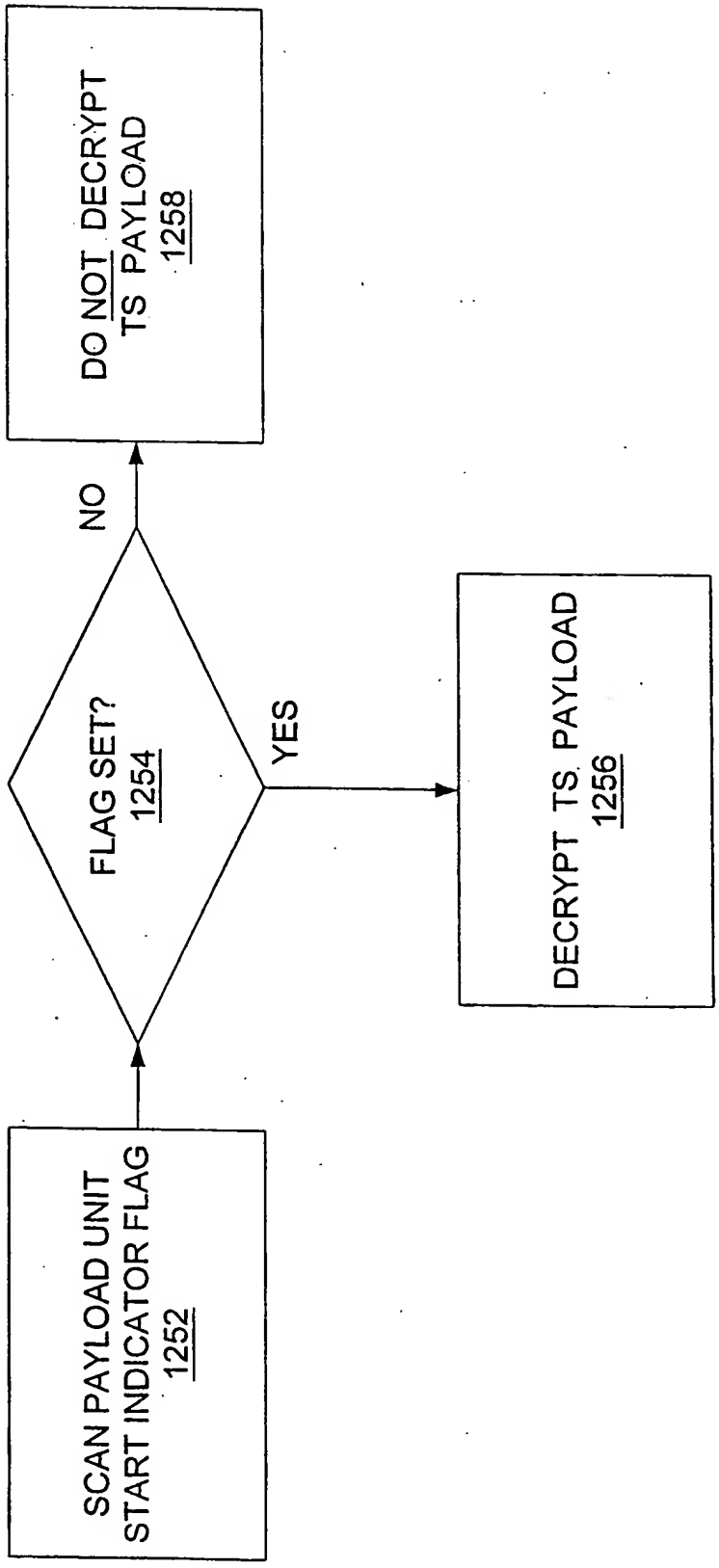
SCAN PAYLOAD UNIT START INDICATOR FLAG 1252
FLAG SET? 1254
NO
YES
DO NOT DECRYPT TS PAYLOAD 1258
DECRYPT TS PAYLOAD 1256
1250

FIG. 12B.

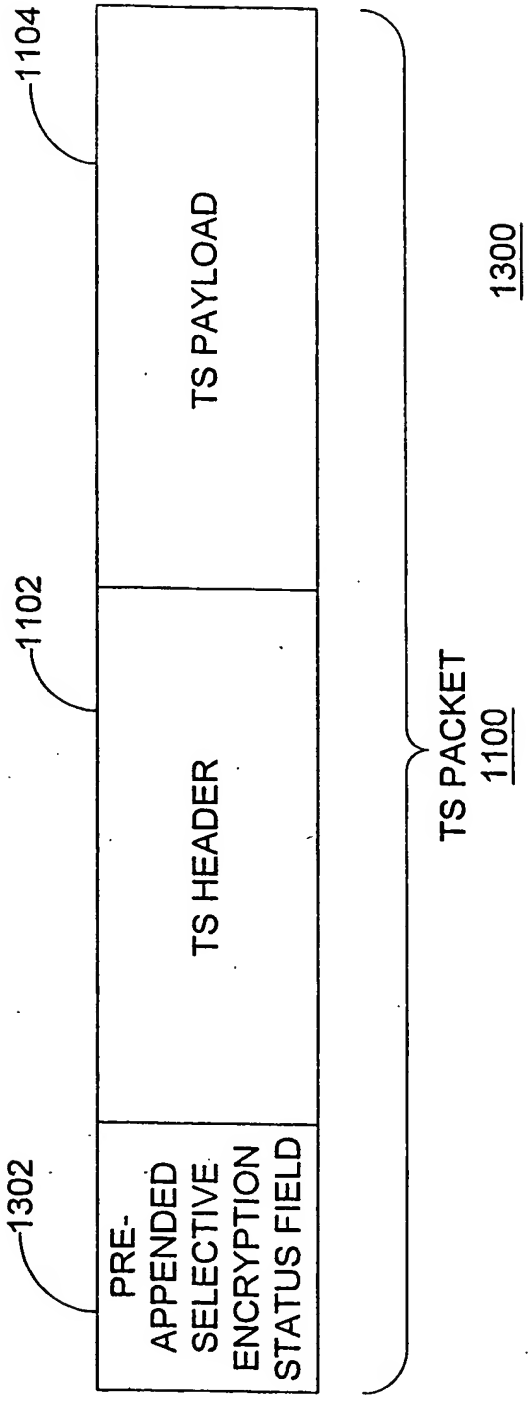
1104
TS PAYLOAD
1102
TS HEADER
1302
PRE-APPENDED SELECTIVE ENCRYPTION STATUS FIELD
TS PACKET
1100
1300

FIG. 13.

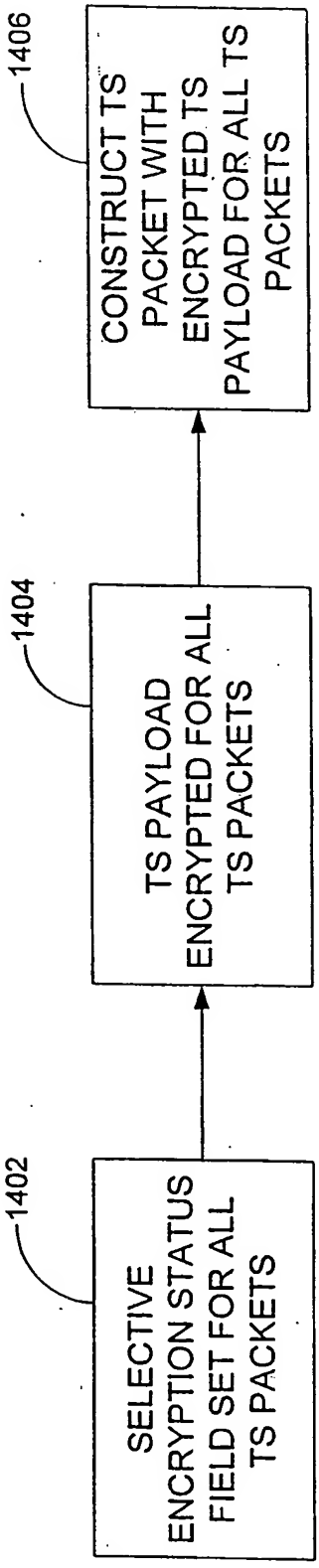
1406
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD FOR ALL TS PACKETS
1404
TS PAYLOAD ENCRYPTED FOR ALL TS PACKETS
1402
SELECTIVE ENCRYPTION STATUS FIELD SET FOR ALL TS PACKETS
1400

FIG. 14A.

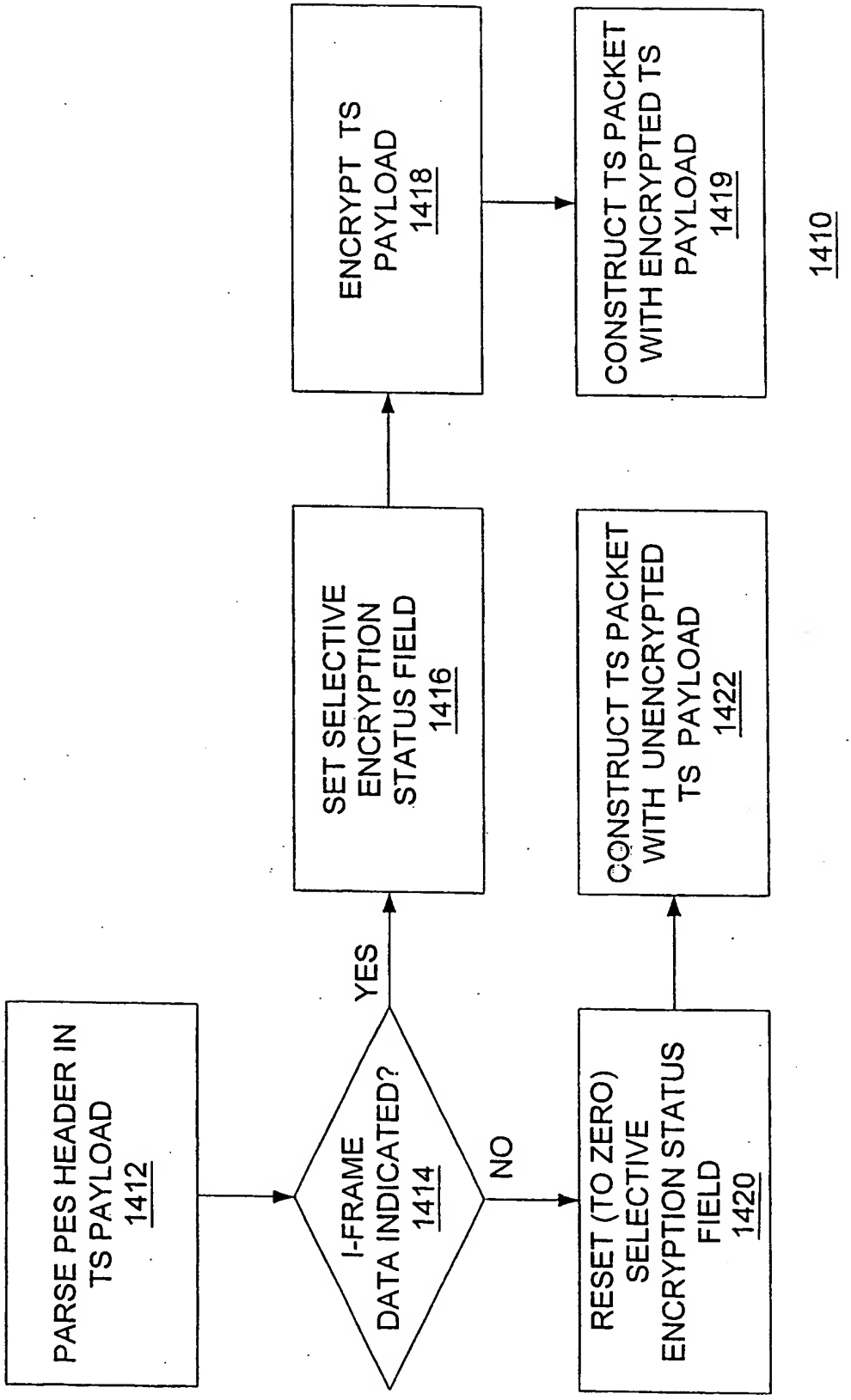
PARSE PES HEADER IN TS PAYLOAD 1412
I-FRAME DATA INDICATED? 1414
YES
NO
SET SELECTIVE ENCRYPTION STATUS FIELD 1416
ENCRYPT TS PAYLOAD 1418
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD 1419
RESET (TO ZERO) SELECTIVE ENCRYPTION STATUS FIELD 1420
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD 1422
1410

FIG. 14B.

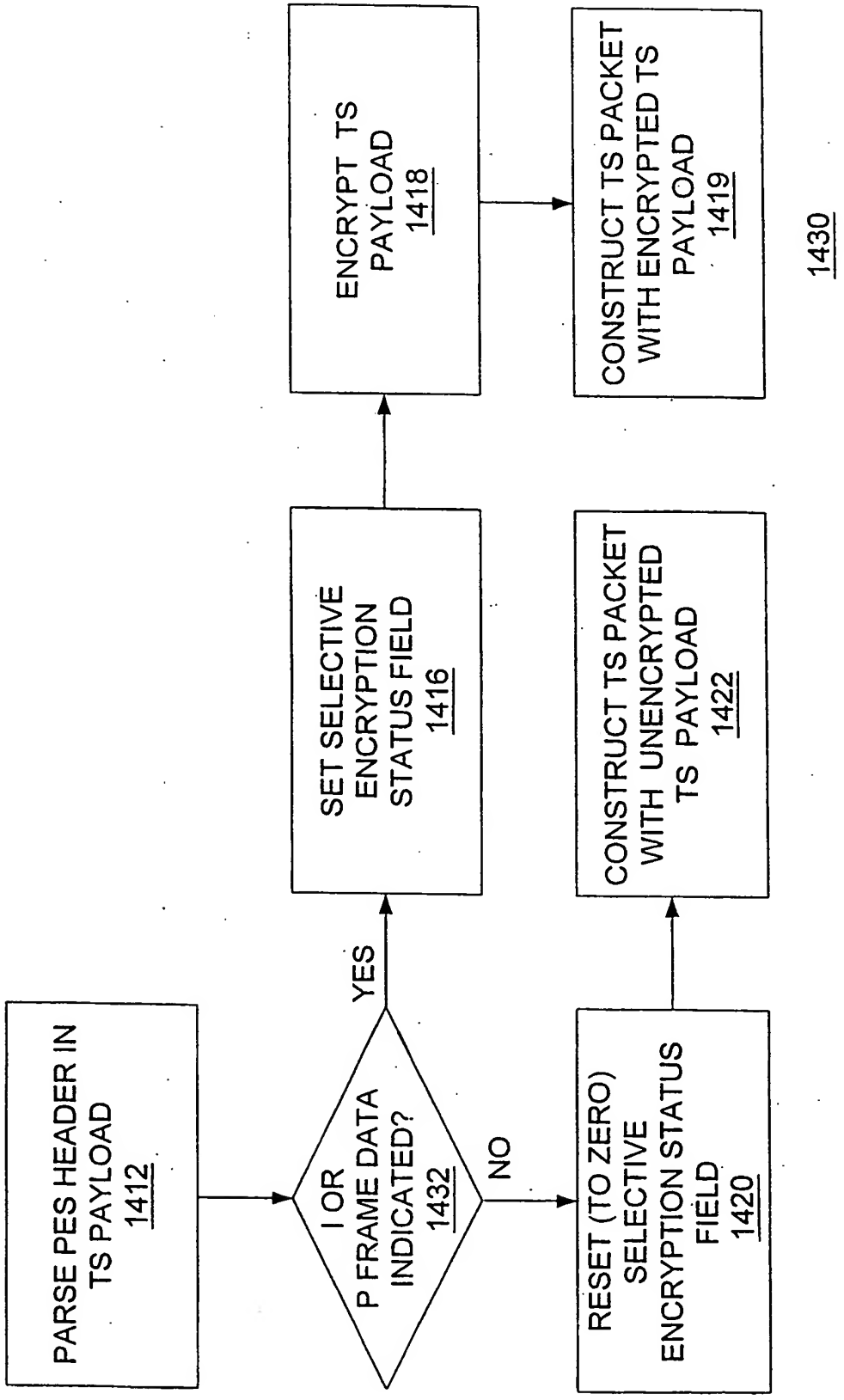
PARSE PES HEADER IN TS PAYLOAD 1412
I OR P FRAME DATA INDICATED? 1432
YES
NO
SET SELECTIVE ENCRYPTION STATUS FIELD 1416
ENCRYPT TS PAYLOAD 1418
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD 1419
RESET (TO ZERO) SELECTIVE ENCRYPTION STATUS FIELD 1420
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD 1422
1430

FIG. 14C.

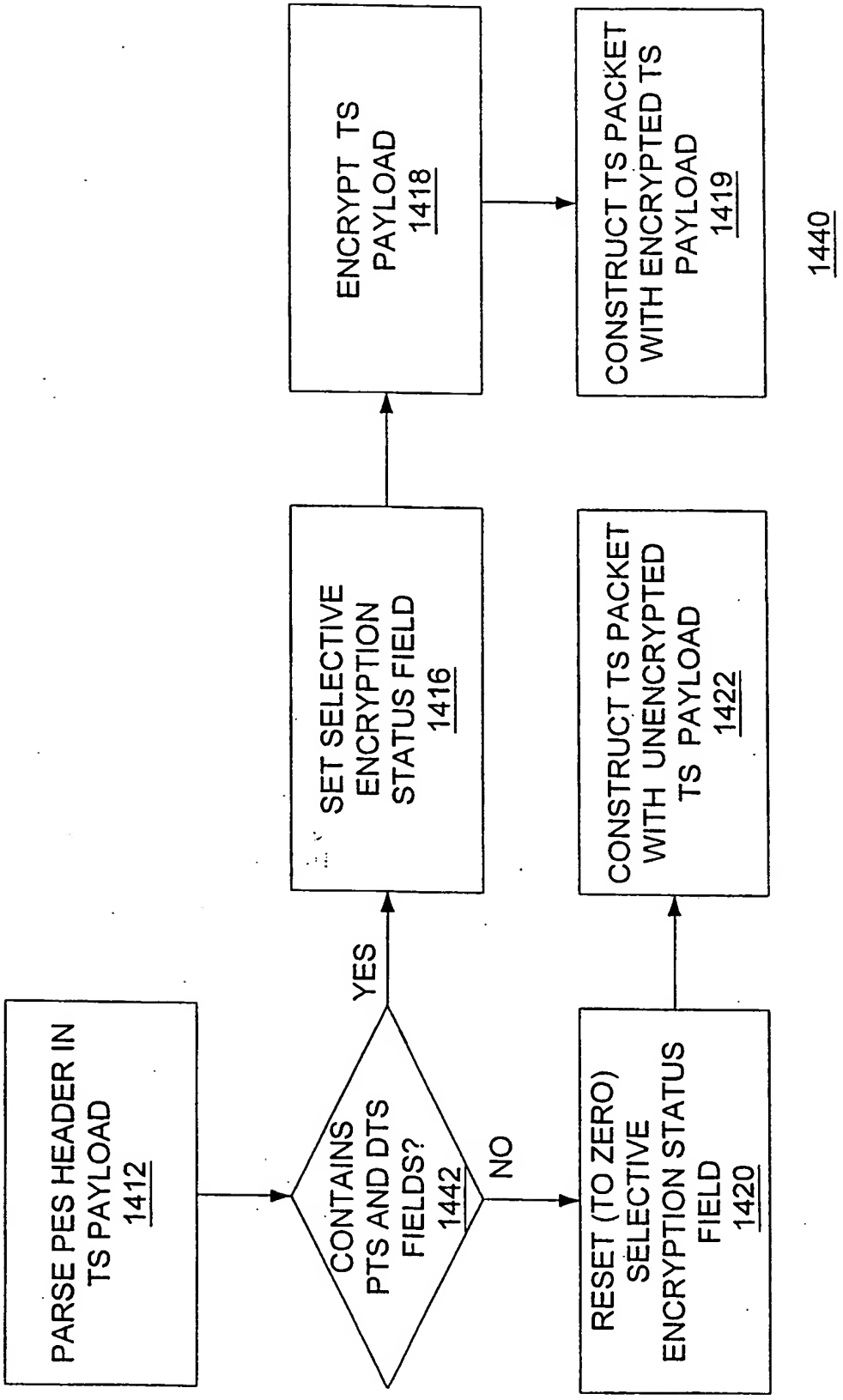
PARSE PES HEADER IN TS PAYLOAD 1412
CONTAINS PTS AND DTS FIELDS? 1442
YES
NO
SET SELECTIVE ENCRYPTION STATUS FIELD 1416
ENCRYPT TS PAYLOAD 1418
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD 1419
RESET (TO ZERO) SELECTIVE ENCRYPTION STATUS FIELD 1420
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD 1422
1440

FIG. 14D.

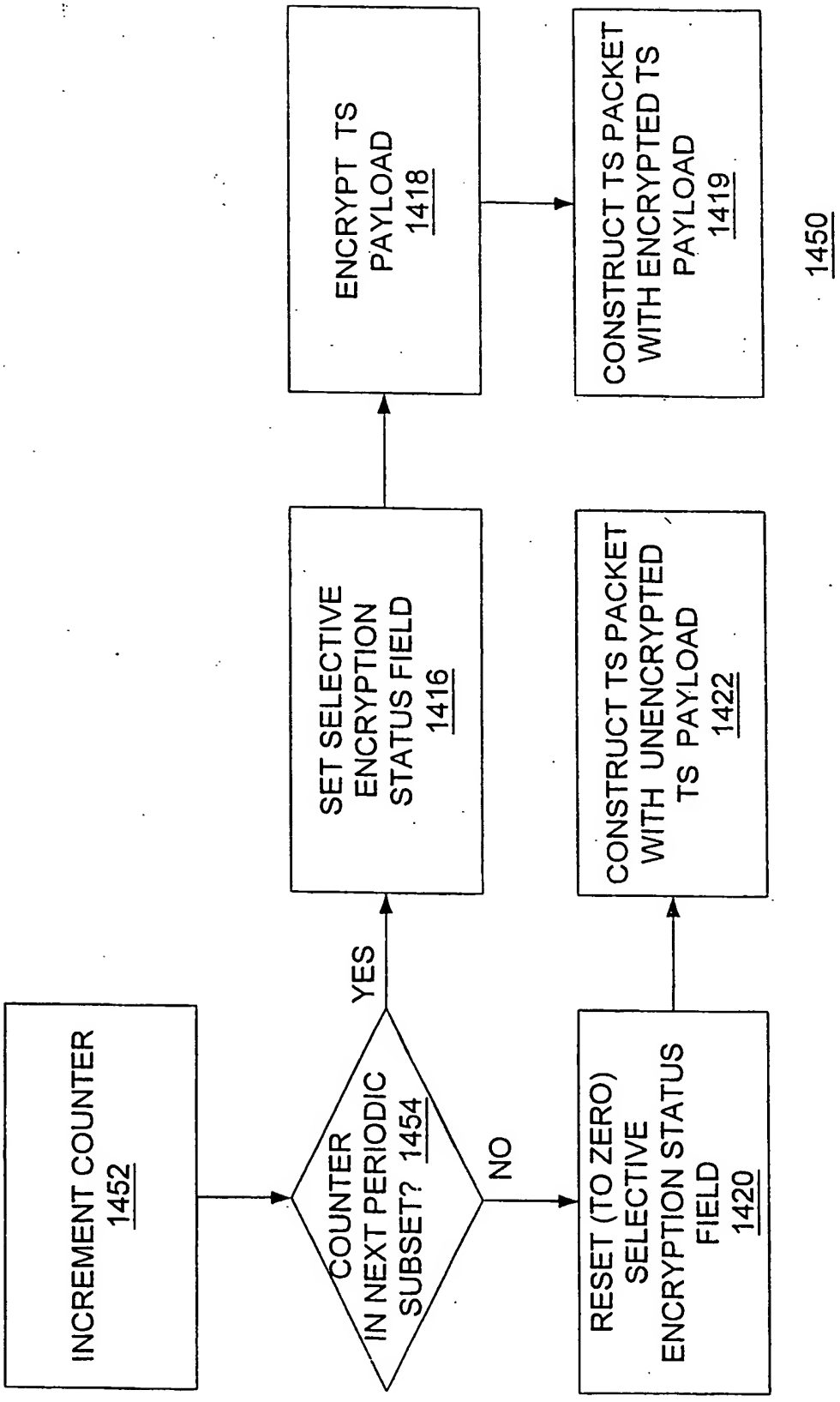
INCREMENT COUNTER
1452
COUNTER IN NEXT PERIODIC SUBSET? 1454
YES
NO
SET SELECTIVE ENCRYPTION STATUS FIELD
1416
ENCRYPT TS PAYLOAD
1418
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD
1419
RESET (TO ZERO) SELECTIVE ENCRYPTION STATUS FIELD
1420
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD
1422
1450

FIG. 14E.

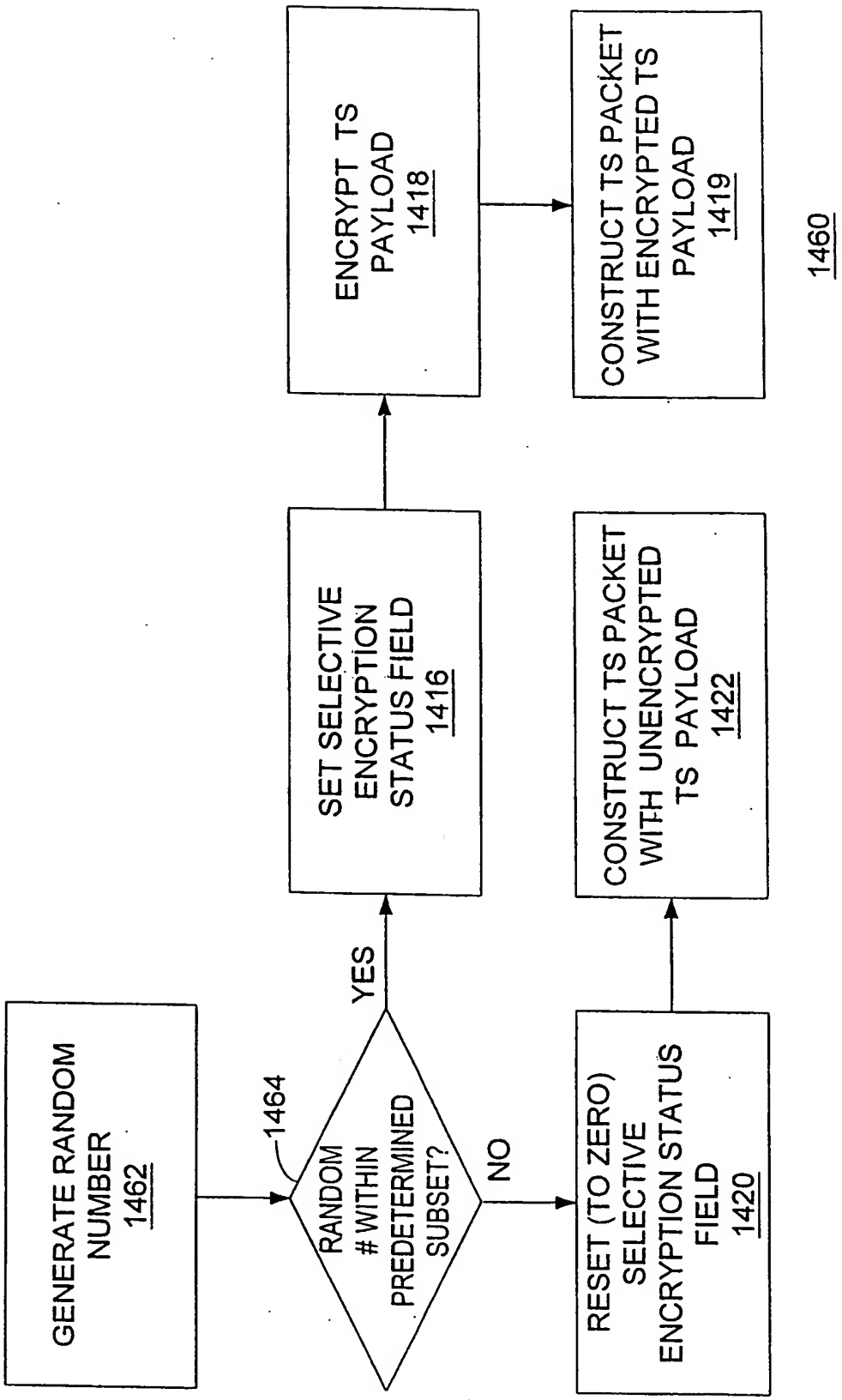
GENERATE RANDOM NUMBER 1462
1464
RANDOM # WITHIN PREDETERMINED SUBSET?
YES
NO
SET SELECTIVE ENCRYPTION STATUS FIELD 1416
ENCRYPT TS PAYLOAD 1418
CONSTRUCT TS PACKET WITH ENCRYPTED TS PAYLOAD 1419
RESET (TO ZERO) SELECTIVE ENCRYPTION STATUS FIELD 1420
CONSTRUCT TS PACKET WITH UNENCRYPTED TS PAYLOAD 1422
1460

FIG. 14F.

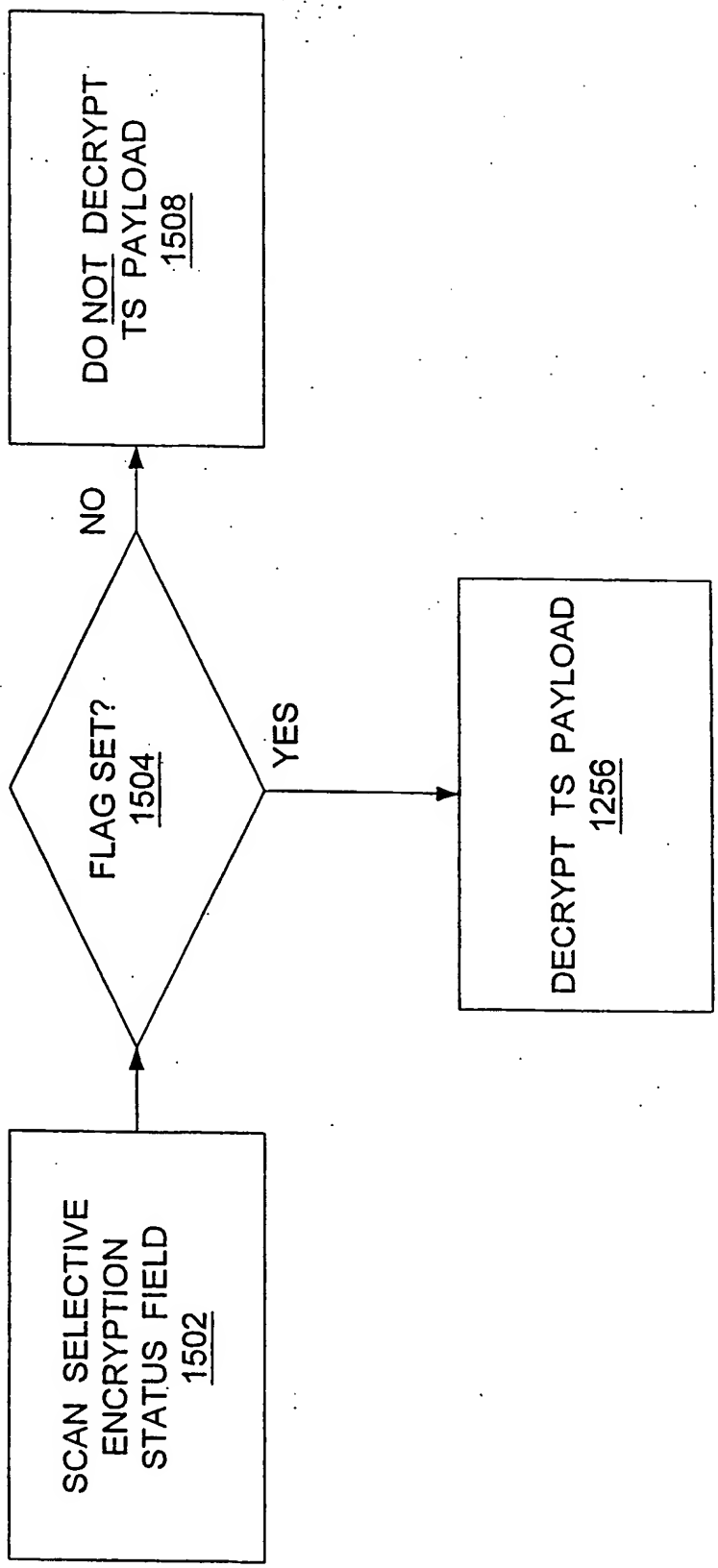
SCAN SELECTIVE ENCRYPTION STATUS FIELD 1502
FLAG SET? 1504
NO
YES
DO NOT DECRYPT TS PAYLOAD 1508
DECRYPT TS PAYLOAD 1256
1500

FIG. 15.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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09/528,580	20 March 2000 (20.03.2000)	US

(71) Applicant: DIVA SYSTEMS CORPORATION [US/US]; 800 Saginaw Drive, Redwood City, CA 94063 (US).

(72) Inventors: COLLIGAN, Michael, Robert; 847 Stella Court, Sunnyvale, CA 94087 (US). SON, Yong, Ho; 535 Arastradero #310, Palo Alto, CA 94306 (US). GOODE, Christopher; 722 Creek Drive, Menlo Park, CA 94025 (US).

(74) Agents: OKAMOTO, James, K. et al.; Townsend and Townsend and Crew LLP, Two Embarcadero Center, 8th Floor, San Francisco, CA 94111-3834 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

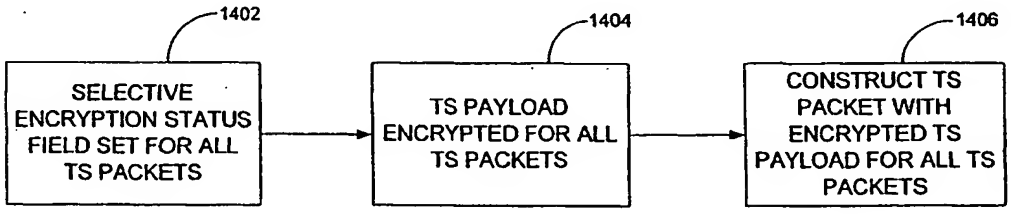
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

(88) Date of publication of the international search report:
19 April 2001

[Continued on next page]

(54) Title: SELECTIVE AND RENEWABLE ENCRYPTION FOR SECURE DISTRIBUTION OF VIDEO ON-DEMAND



1400

(57) Abstract: Selective encryption is provided in a process which includes: determining whether a predetermined criterion is satisfied; setting a selective encryption status field (1402) if the predetermined criterion is satisfied; and encrypting an unencrypted payload to generate an encrypted payload, and constructing a packet with the encrypted payload (1406), if the predetermined criterion is satisfied. The predetermined criterion may be one of several criteria, each of which reduce the required amount of encryption and decryption while maintaining a high level of security. Renewable encryption is provided in a process which includes: copying a first encrypted digital video program from a remote server to a video source; decrypting the first encrypted digital video program using a first key to generate an unencrypted digital video program; encrypting the unencrypted digital video program using a second key to generate a second encrypted digital video program; transmitting the second encrypted digital video program from the video source to the remote server; and deleting the first encrypted digital video program from the remote server.

WO 00/60846 A3

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/09045

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04L 9/00
US CL :380/200; 713/150,154,160

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 380/200; 713/150,154,160

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,721,778 A (KUBOTA et al) 24 February 1998, col. 4, lines 57-63; col. 5, lines 18-25; col.5, line 48 to col. 7, line 22.	1-15
Y	US 5,666,487 A (GOODMAN et al) 9 September 1997, col. 14, lines 30-62; col. 19, lines 19-57; col. 20, lines 10-20.	1-15
Y	US 5,420,866 A (WASILEWSKI) 30 May 1995, col. 9, line 7 to col. 13, line 34.	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 29 AUGUST 2000	Date of mailing of the international search report 13 OCT 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer TOD SWANN Telephone No. (703) 308-9293

Form PCT/ISA/210 (second sheet) (July 1998)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/09045

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-15

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/09045

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I, claim(s)1-15, drawn to deciding how to transmit digital video programs based on predetermined criterion.
Group II, claim(s) 16-23, drawn to preparing digital video programs for future transmission.
Group III, claim(s) 24, drawn to scheduling and tracking distributed digital video programs.

The inventions listed as Groups I, II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention is the predetermined criterion while the special technical feature of the Group II invention is the steps for preparing the programs while the special technical feature of the Group III invention is the scheduling and tracking of the keys used to encrypt and decrypt the programs. Since the special technical feature of the Group I invention is not present in the Group II invention or Group III invention being claimed, unity of invention is lacking. Further, the special technical feature of the Group II invention is not present in the Group I invention or Group III invention being claimed and the special technical feature of the Group III invention is not present in the Group I invention or Group II invention being claimed, thus unity of invention is lacking.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04N

A2

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(30) Priority Data:

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60/131,162	26 April 1999 (26.04.99)	US
09/528,580	20 March 2000 (20.03.00)	US

(71) Applicant: DIVA SYSTEMS CORPORATION [US/US]; 800 Saginaw Drive, Redwood City, CA 94063 (US).

(72) Inventors: COLLIGAN, Michael, Robert; 847 Stella Court, Sunnyvale, CA 94087 (US). SON, Yong, Ho; 535 Arastradero #310, Palo Alto, CA 94306 (US). GOODE, Christopher; 722 Creek Drive, Menlo Park, CA 94025 (US).

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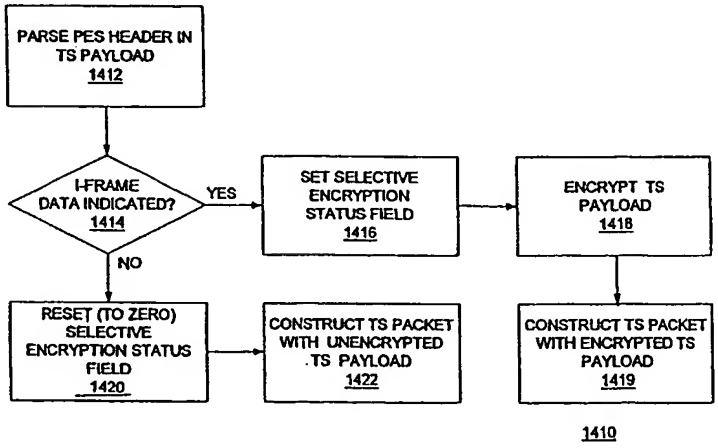
(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

Without international search report and to be republished upon receipt of that report.

(54) Title: SELECTIVE AND RENEWABLE ENCRYPTION FOR SECURE DISTRIBUTION OF VIDEO ON-DEMAND



(57) Abstract

Selective encryption is provided in a process which includes: determining whether a predetermined criterion is satisfied; setting a selective encryption status field if the predetermined criterion is satisfied; and encrypting an unencrypted payload to generate an encrypted payload, and constructing a packet with the encrypted payload, if the predetermined criterion is satisfied. The predetermined criterion may be one of several criteria, each of which reduce the required amount of encryption and decryption while maaintaining a high level of security. Renewable encryption is provided in a process which includes: copying a first encrypted digital video program from a remote server to a video source; decrypting the first encrypted digital video program using a first key to generate an unencrypted digital video program; encrypting the unencrypted digital video program using a second key to generate a second encrypted digital video program; transmitting the second encrypted digital video program from the video source to the remote server; and deleting the first encrypted digital video program from the remote server.

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SELECTIVE AND RENEWABLE ENCRYPTION FOR SECURE DISTRIBUTION OF VIDEO ON-DEMAND

CROSS-REFERENCES TO RELATED APPLICATIONS

The present application is based on provisional application "Selective Encryption," Serial No. 60/131,162, filed April 26, 1999, by inventors Michael Colligan, Yong Ho Son, and Christopher Goode. The present application is also based on provisional application "Time Dependency on Pre-Encryption for Video On-Demand Systems," Serial No. 60/128,224, filed April 7, 1999, by inventor Yong Ho Son. In addition, the present application is a continuation-in-part of utility application "Secure Distribution of Video On-Demand," Serial No. 09/267,800, filed March 12, 1999, by inventors Yong Ho Son and Christopher Goode.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of video distribution networks. In particular, this invention relates to secure video distribution networks.

2. Description of the Background Art

Security is an important issue for video distribution networks. Issues of security are particularly important with regards to the distribution of digital video.

Distribution of digital cable television channels currently follows a broadcast model in that the digital cable television channels are broadcast from the broadcast source to many subscriber stations at once. Security for the distribution of

digital cable television channels also follows a broadcast model. A digital cable television channel is fully encrypted in real-time at the time of the broadcast from the broadcast source. Authorization keys allow subscribing users to decrypt and view the broadcast content. Such authorization keys must somehow, at sometime, be delivered to the subscribing users. It is not practical to deliver authorization keys at the same time that encrypted content is broadcast because verification of the delivery is difficult to do immediately and interactively using current cable television networks. Hence, delivery of the authorization keys occurs periodically on a time-based schedule, where the periodicity of the delivery is known as a time quantum or time epoch. The time epoch is typically related to the billing cycle (for example, monthly) for the cable television service.

Unlike distribution of digital cable television channels, distribution of digital video on-demand (VOD) follows a pointcast model in that the content is transmitted from a video server to each individual viewer. Due to the nature of pointcasting, a security scheme for digital VOD which is based on the model provided by security for cable television broadcasts would be impractical and expensive. First, fully encrypting the digital VOD in real-time every time the digital video is transmitted from the server to an individual viewer is quite expensive in both cost and space usage for encryption equipment. Second, having a time epoch correlated to the billing cycle of the digital VOD service (for example, monthly) is a scheduling scheme that may create security risks which inhibits optimal protection of the content.